Designing for Low-literacy Users: a Framework for Analysis of User-Centred Design Methods

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Technology has the potential to improve the lives of marginalised communities from poor regions of the world, especially those with low-literacy skills. For that to happen, users' needs and characteristics should not be considered only as requirements, but also be incorporated in the software development process itself. Although there is a significant amount of research on the theme, the subject is complex and the knowledge produced by the community lacks systematisation. This thesis is an attempt to make that complexity more manageable. A succinct but comprehensive framework for analysis of methods was created from an extensive literature review of recent research on the topic, to guide researchers in their choices of methods to apply when developing for low-literacy users from poor regions. To exemplify its use and application, the framework is used to evaluate methods that could support the development of applications when users are geographically separated from the research team.

Key words and terms: illiteracy, functional illiteracy, low-literacy skills, evaluation of methods, methodologies, distance design, user-centred design, human-computer interaction

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1. Introduction

A striking characteristic of today's world is the increasing gap between the haves and the have-nots. This inequality is not only related to income, but also to disparities in the access to essential goods and services: food, shelter, clean water, health care, education. As the world embraces the so-called digital age, access to computers and to the internet has been added to this list. Among many other divides, we now hear and read about *digital divide*, the gap between those who can access information and communication technologies to improve their lives and those who cannot.

Awareness about the digital divide has affected the technology development field. Information and Communication Technology for Development, or ICT4D, is an already wide-spread term used to refer to the multidisciplinary research area interested in the application of technology to foster development in poor regions.

ICT4D research has been evolving from a technocentric approach to one that tries to better understand the environment to deliver effective change. It is now understood that the digital divide is not caused solely by the lack of physical access to devices and computers. Even more pertinent is the lack of the skills needed to access content and to interact with computers, in particular the very ability of reading what the computer screen shows. This is not surprising, considering the very high illiteracy rates found in the developing world. As of 2007, one sixth of the world's adult population was considered illiterate; 99% of those 770 million people live in developing countries (UNESCO Institute for Statistics, n d). In addition to absolute illiteracy, developing countries also face the problem of functional illiteracy, which highly affects digital inclusion as well. For example, in Brazil, around one third of the adult population is considered functionally illiterate (INAF, 2007).

Due to its recognition as one of the main causes of the digital gap, illiteracy is becoming a recurring theme within ICT4D research. Since the beginning of the new millennium, an increasing number of studies have been trying to address the needs of illiterate users. Some of these research efforts resulted in prototypes of text-free technologies aimed at certain regions, mainly in India and Africa, while others looked into more general aspects, such as cognitive abilities of functionally illiterate users. Still, one point was common between all of them: they agreed that work targeted at illiterate or functionally illiterate users cannot be carried out in the same way as projects for the developed world are.

It is already well recognised that in order to successfully create technology for users in developing countries, regardless of whether they are illiterate or not, those users' needs and characteristics should not be considered only as hardware or software requirements, but also be incorporated in the whole process itself (Baker et al., 2006; Maunder et al., 2006; Bednarik et al., 2007). The most widely accepted view is that the best, if not the only way of doing so is by going to the poor regions and employing techniques based on ethnographic work and participatory design. As Genevieve Bell puts it:

> "If you want to develop new technologies or innovate old technologies for different contexts, you're crazy if you don't go to those contexts. If you want to build something for Mexico, go to Mexico. If you want to think about what a piece of technology looks like in Nairobi or Cairo or rural South Australia, you have to go those places because your own imaginings of them are often profoundly flawed." (Baker et al., 2006)

Bell's strong statement reflects the predominant view among ICT4D researchers, further demonstrated by current practice: the vast majority of the projects targeting poor regions do include research done locally. However, if this was completely true, it would represent a severe limitation for most research groups interested in technology for development. What happens when a project aimed at a specific target group faces financial, geographical or time-related limitations that make it impossible to travel to those contexts?

While it is indisputable that physical proximity to the reality to be studied is desirable, believing that it is the only way might also be counter-productive. On the one hand, it can be discouraging for many smaller research groups and students who wish to devote their attention to technology for development, but lack financial resources to conduct the research *in loco*. On the other hand, it can lead to the assumption that physical presence alone is guaranteed to redeem valid results, which is definitely not true.

Research shows that it is possible to design at a distance for illiterate users in the developing world. At least one methodology has been created to address that question directly: Huenerfauth's Hypothetical User Design Scenarios (2002b). Other

researchers, such as Goetze and Strothotte (2001) and Deo et al. (2004), faced similar limitations and produced solutions to cope with the constraints. Nevertheless, those examples are very few and scattered. Researchers and designers still lack better reference sources to guide them on how to build applications and conduct such projects when access to those realities is not possible or very limited.

This thesis aims to contribute one more building block to fill that gap. To that effect, it presents a tool to guide researchers in planning how to conduct their projects aimed at the developing world: a succinct but comprehensive framework for analysis of User-Centred Design (UCD) methods, to evaluate their applicability when elaborating interfaces and devices for low-literacy users. Created from an extensive literature review of recent research on the topic, the framework condenses and organises knowledge and experience acquired over the past few years by several teams working with ICT4D.

Because of its practical nature, the framework is particularly useful to support decision-making in situations where unfavourable circumstances, such as limited time and money, demand careful and thoughtful planning to utilise available resources effectively. It can also have a more theoretical application, contributing to improvement of existing methods to better support development for low-literacy users. In addition, many of the considerations raised by the framework are rather general, being useful not only in projects targeting low-literacy users, but also in any work that aims to put the user in the centre of the development.

The text is organised as follows. The history and current state of the research on ICT4D are briefly addressed in Chapter 2. Chapter 3 explores in more depth the issue of illiteracy and functional illiteracy, highlighting how low literacy skills contribute to digital divide and giving an overview of previous research on designing technology for illiterate and functionally illiterate users. The User-Centred Design (UCD) approach is explained in Chapter 4, as it is the paradigm on which this work is based. Chapter 5 describes, step by step, the methodology used in the thesis. The actual analysis starts in Chapter 6, *Development of ICTs for low-literacy users in poor regions*, where the most relevant issues selected from the literature on the theme are presented. Next, Chapter 7 presents the main contribution of this thesis, the framework for analysis of UCD methods. In Chapter 8, the framework is applied to a set of methods to demonstrate how it can be useful in practice.

In Chapter 9, *Discussion*, the outcomes and limitations of this work are discussed. Finally, Chapter 10, *Conclusions*, summarises the work, evaluating its relevance and contribution and making suggestions for further research.

2. Information and Communication Technologies for Development

Information and Communication Technologies for Development, or ICT4D, is a relatively new multidisciplinary field of study that investigates how the use of technology can improve the lives of marginalised people living in poorer regions of the world. Its scope is not restricted to technology itself—it also encompasses how communication and access to information can empower poor people and make a difference in their everyday lives.

There is much debate around what "development" means in this context. Some scholars challenge the dominant model of economic growth, closely related to the concept of globalisation, as it mostly ignores culture differences, characteristics of local contexts and the importance of participation and empowerment (Unwin, 2009, pp. 1; 14-15). Regardless of the differences in understanding, however, there is a common aspiration to ameliorate the lives of poor people by trying to eliminate problems such as poor health, illiteracy and lack of access to education, and improving political participation (Toyama, 2010).

According to Heeks (2008), it is usually accepted that the establishment of ICT4D as a research field happened in the 1990s, with the sudden increase in internet usage and the incorporation of economic development of poor countries in the political agenda of international organisations. The intention to support development first appeared in the report "Shaping the 21st century: the contribution of development co-operation" (OECD, 1996), and then was accepted by the United Nations General Assembly as one of the Millennium Development Goals (MDG) in September 2000.

In what is regarded as the first phase of ICT4D, the focus lied on providing access to technology in poor areas; this goal manifested in the appearance of telecentres, or community computer centres, in poor areas. This model, however, proved to be neither effective nor sustainable, and many projects were victims of a technocentric approach that did not recognise the need for sustainability, scalability and impact evaluation of efforts aimed at fostering development in poor regions. As the lessons were being learned from the first failures, researchers started considering the

larger context of the application of information and communication technologies—what are the human, political and contextual factors, what are the interests of each group involved—and also how technologies fit within the development processes. (Warschauer, 2002; Heeks, 2008; Unwin, 2009)

In the words of Heeks:

> "Where 1.0 imposed pre-existing designs and expected the poor to adapt to them, 2.0 designs around the poor's specific resources, capacities, and demands. Or, we can transform 'the network is the platform' to argue that while ICT4D 1.0 saw ICTs as a tool for development, the second phase sees ICTs as the platform for that development." (Heeks, 2008)

The changes in the view on ICT4D reflected also in academic research, which started to better acknowledge the context and to consider infrastructure possibilities and limitations. Mobile phones gained a lot of attention in ICT4D research due to their large and still growing presence in poor areas (Toyama, 2010). More importance started to be given to converting members of the local community into content producers and to providing services to poor people, especially related to e-government and mobile banking (Heeks, 2008).

The multi-sectoral nature of ICT4D started to be considered more seriously, especially the importance of contemplating the needs of all stakeholders. Contrary to traditional application of Human-Computer Interaction (HCI), which typically involves private sector and academia, ICT4D affects several different groups: target communities, civil society, development providers (governments, non-governmental organisations, commercial entities), funding entities and regulators, and, of course, ICT researchers. Bringing those groups together in the development process is always a challenge in an ICT4D project. (Tongia and Subrahmanian, 2006; Toyama, 2010)

ICT4D is recognised as an important theme among the information technology research community, and, consequently, there are acknowledged forums for academic discussion on the use of ICTs in developing countries. Two of the most important ones are IEEE/ACM International Conference on Information and Communication Technologies and Development (ICTD) and International IFIP WG9.4 Conference.

IFIP also organises the World Information Technology Forum (WITFOR), in cooperation with local governments in developing countries. In addition to encouraging academic debate and experience sharing, WITFOR aims to influence the agenda of organisations and governments. This is the reason why it promotes a more active participation of the many different stakeholders affected by ICT4D, and not only academia and private sector.

ICT4D is a broad discipline, one that involves more than just software development for low-literacy users. Nevertheless, due to the high rates of illiteracy found in poor regions of the world, there is a lot of overlapping between the two fields. The considerations raised by ICT4D studies are important to contextualise the development of applications for low-literacy users. Even though those two areas have many similarities, they are not identical. The next chapter gives an overview of the development of applications specifically aimed at low-literacy users, mostly in developing countries, but also for low-literacy users from richer countries.

3. Illiteracy and functional illiteracy

3.1 Illiteracy and functional illiteracy in the world

Literacy, as defined by the Oxford English Dictionary, means "the quality or state of being literate; knowledge of letters; condition in respect to education, especially ability to read and write". Literate, according to the same dictionary, means "acquainted with letters or literature; educated, instructed, learned", or simply "one who can read and write, opposed to illiterate".

However, the need for a more complete understanding of literacy had already been perceived in the mid-1960s, when the campaigns for eradication of illiteracy and their follow-up studies showed that short-term, top-down approaches focusing on teaching a set of technical skills—reading and writing—were not the solution for the problem of illiteracy. Therefore, the term "functional illiteracy" was created, and campaigns for promoting literacy started to be linked with socio-economic development programs. (UNESCO, 2004)

Further studies continued to develop the theme, and many of them discussed literacy taking the social context into consideration. Some studies, such as the one presented by Scribner and Cole (1981), were built from the analysis of the usage of literacy by specific societies, reaching the conclusion that literacy "is not simply knowing how to read and write a particular script but applying this knowledge for specific purposes in specific contexts of use" (Scribner and Cole, 1981, p. 236). Other researchers, such as Paulo Freire, took a critical view of the subject, by relating literacy not only to the context of the person's life but also recognising the influence that society as a whole, and its inherent inequalities, has on literacy. (Barton, 1994)

Nowadays, the general approach towards adult illiteracy follows the tendency started in the 1960s. For example, the Organisation for Economic Co-Operation and Development (OECD) defines literacy as a multiplicity of skills that gives "the ability to understand and employ printed information in daily activities, at home, at work and in the community—to achieve one's goals, and to develop one's knowledge and potential" (OECD, 2000, p. x).

In practical terms, a person is no longer seen as either literate or illiterate; instead, more and more programmes are employing methods that assess literacy on

scales of proficiency. The most important example of this change in the methodology used to collect data about illiteracy is the work being carried out by the UNESCO Institute for Statistics. In an effort to allow for better comparison between the statistics of each country, the UNESCO Institute for Statistics started the Literacy Assessment and Monitoring Programme (LAMP). LAMP is a framework intended to be used as a basis for comparison of adult literacy in several countries in the world, in both developed and developing countries. In LAMP, five levels of proficiency are identified within four domains: prose literacy; document literacy; numeracy; and component skills consisting of reading, writing and numeracy skills (UNESCO Institute for Statistics, 2005b). Table 1 lists each level and their descriptions.

Level	Description
Level 1	Indicates persons with very poor skills, where the individual may, for example, be unable to determine the correct amount of medicine to give a child from information printed on the package.
Level 2	Respondents can deal only with material that is simple, clearly laid out, and in which the tasks involved are not too complex. It denotes a weak level of skill, but more hidden than Level 1. It identifies people who can read, but test poorly. They may have developed coping skills to manage everyday literacy demands, but their low level of proficiency makes it difficult for them to face novel demands, such as learning new job skills.
Level 3	Is considered a suitable minimum for coping with the demands of everyday life and work in a complex, advanced society. It denotes roughly the skill level required for successful secondary school completion and college entry. Like higher levels, it requires the ability to integrate several sources of information and solve more complex problems.
Levels 4 & 5	Describe respondents who demonstrate command of higher-order information processing skills.

Table 1: Literacy levels identified by the LAMP framework (UNESCO Institute for Statistics, 2005a)

In Brazil, a yearly survey called the National Functional Literacy Indicator (NFLI, or INAF in the Portuguese acronym), carried out by two non-governmental organisations, evaluates literacy skills in the country. This survey identifies four levels of literacy related to two dimensions: reading and writing abilities, and mathematical abilities (see Table 2). (INAF, 2007)

Level	Reading and Writing abilities	Mathematical abilities
Illiterate	Unable to perform simple tasks that require decoding of words and sentences.	Unable to perform basic operations with numbers such as reading the price of a product or writing down a telephone number.
Rudimentary literacy	Able to locate explicit information in very short texts, where the layout helps recognizing the content (for example, in an advertisement, locating the date when a vaccination campaign starts or the age from which the vaccine can be taken).	Able to read numbers in specific contexts such as prices, timetables, telephone numbers, etc.
Basic literacy	Able to locate information in short and medium-length texts (for example in a letter complaining about a broken refrigerator, the person is able to identify what the defect is).	Able to completely master the reading of numbers; to solve usual operations involving adding, subtracting and even multiplying; and to easily use the calculator. Unable to identify the existence of proportionality relationships.
Full literacy	Able to read long texts and to be guided by subtitles; to locate more than one piece of information, according to pre-established conditions; to relate parts of a text; to compare two texts; to make inferences and syntheses.	Able to control a strategy to solve more complex problems, with the execution of a series of related operations. Presents familiarity with maps and graphs. Shows no difficulties related to mathematics.

Table 2: Literacy levels identified by NFLI in Brazil, translated from Portuguese (INAF, 2007)

The levels of literacy identified by the NFLI are slightly different to those defined in the LAMP framework, although the main idea remains the same. NFLI clearly differentiates illiteracy and rudimentary literacy (or functional illiteracy), while the LAMP framework classifies illiteracy and very poor literacy skills together as Level 1. In both frameworks, the first two levels of the scale indicate low-literacy skills, considered insufficient for an individual to cope with everyday demands of life in a complex society (OECD, 2000).

The change in the understanding about levels of literacy is widely accepted in theory, but in practice gathering new data according to the new methodology takes time. As many countries still have not implemented measurement programmes as suggested by UNESCO, or are in the process of collecting new data, most of the statistics available today still refer to the dichotomous figures of literates and

illiterates. Consequently, many functionally illiterate people are classified as literate in the statistics available today. Thus, it is important to keep in mind that the figures largely under-estimate the actual situation of adult illiteracy. UNESCO statistics indicate that about 18% of the world's population is illiterate. Of these, 99% live in developing countries (UNESCO Institute for Statistics, 2008). Although the most alarming numbers are concentrated in South and West Asia, sub-Saharan Africa, East Asia and the Pacific, developing countries such as China, Brazil and India still show significantly high adult illiteracy rates: 6,7%, 9,5% and 34%, respectively. Together, those three countries have roughly 350 million adults who cannot read at all. (UNESCO Institute for Statistics, n d)

Although slightly outdated, studies that investigated illiteracy not as an on/off characteristic but as levels of proficiency help us understand the real dimensions of the problem. Complete illiteracy rates are very small in the developed world, but a significant percentage of the population of those countries can be considered functionally illiterate. In countries such as Australia, Canada, the Czech Republic, Hungary, Portugal, Switzerland, United Kingdom and the United States, the percentage of adults that have only the lowest level of literacy is at least 15%; the Nordic countries and Germany have between 7% and 15% of the adult population with the most rudimentary literacy level (OECD, 2000).

In Brazil, the percentage of the population considered illiterate or with a rudimentary level of literacy is 32% (INAF, 2007)—almost one third of the population of the country.

3.2 Illiteracy, accessibility and the information society

There is a growing world-wide movement towards what has been called e-government, caused by the ever increasing usage of the internet. E-government is an initiative to "provide public services to empower citizens and communities through information technology, especially through the internet" (Ho, 2002).

Especially in the context of e-government, the importance of accessibility for all is highly recognised and taken seriously. In Europe,"designing for all" has been recognised by the European Commission as a concept to be taken into consideration in the design of Information and Communication Technology (ICT) products.

Digital inclusion, or "e-Inclusion", is also being promoted as one of the main themes addressed by the Commission (European Commission, 2005). Among the objectives set in June 2006 by the Riga Ministerial Declaration on e-Inclusion, special emphasis has been given to making ICTs available to minorities such as the people with disabilities and elderly people. In Brazil, a presidential decree obliges all websites from the public administration to follow the Electronic Government Accessibility Model (e-MAG), a set of guidelines to standardise and ease the process of creating accessible sites for as many people as possible (Brazilian Government, 2007).

Considering the numbers regarding illiteracy and functional illiteracy in both developed and developing countries, it is clear that such efforts to promote e-Inclusion should address the needs of that population group as well. In the World Wide Web Consortium (W3C) recommendations for web accessibility there are items that already provide guidelines that are beneficial to low-literacy users, such as using clear and simple language and using supplemental illustrations (W3C/WAI Resource, 2005).

While following the W3C guidelines is indeed beneficial to users with low literacy skills in the context of general websites, in e-government portals and services it is definitely not enough. There is no guarantee that the site will be usable, or it might be usable with a lot of difficulty, which might cause the user to avoid accessing it at all. Not providing access for this social group means that those who probably need the service the most will remain excluded.

3.3 Information systems for the illiterate

In the past decade, some researchers have already approached the issue of providing information systems and services to users who are illiterate or functionally illiterate. This section lists briefly some of the efforts directed to this group of users, highlighting the main problems and solutions that the groups found in each case.

One of the earliest studies aimed specifically at functionally illiterate users was a work by Goetze and Strothotte (2001). The authors developed a list of principles for building a web browser for such users, employing graphical reading aids. They also created and evaluated a prototype of a browser that presented those graphical aids in three different forms: pictures that were displayed when the users pointed

the mouse at a text that they did not understand; pictures replacing text that would be potentially hard for users to understand, with text displayed dynamically when users pointed the mouse at the image; and text and image displayed at the same time. Their research is based both on works that examined pictorial communication aids and on interviews with teachers of illiterate adults in Germany.

Subsequent research efforts aimed at illiterate and functionally illiterate users started to employ not only graphics as suggested by Goetze and Strothotte, but also audio and speech to different levels, ranging from pre-recorded voice annotations to speech-based dialogue interfaces.

Deo et al. (2004) envisioned a system to provide library access to multimedia content (audio, video and photographs) for illiterate users in New Zealand. Their interface allows illiterate users to browse through a collection of photos. They modified an existing digital library software, enhancing it to include audio help on navigation and audio descriptions of images, activated by mouse-over.

In the same fashion, Medhi et al. (2006) created a text-free interface for a community of illiterate domestic labourers in slums in Bangalore, India. The main goal of the research was to allow novice illiterate users to use the system without the need for any assistance. The authors explain that although such a goal was not achieved, they believe that the research has contributed towards a better understanding of the subtleties when creating user interfaces for illiterate and functionally illiterate users. The system was heavily based on illustrations and photographs to convey visual information, as well as on voice annotations to replace text. Their research led to further investigation about optimal ways of using audio-visual representations for illiterate computer users (Medhi et al., 2007).

Enhancing the interface with voice was also one of the techniques employed by Taoufik et al. (2007) when developing an e-government service to deliver birth certificates to citizens, available in a kiosk with a touch-screen. As the service was supposed to be usable by literate and illiterate citizens alike, the textual components of the interface were kept. In addition, the interface provided images, voice recordings of the text (that is also highlighted in colour as it is read to the user) and a step-by-step voice guide to help illiterate users.

Plauche et al. (2006) investigated the feasibility of developing a spoken dialogue system to provide agricultural information to a community in rural India, examining

how to collect data at a low cost to improve the accuracy of automated speech recognition, ultimately reducing the difficulties that dialectal variations and literacy levels can pose to speech-based interfaces in developing areas. Along the same lines, Ndwe et al. (2008) described a health care interactive voice response system aimed at caregivers of children infected with HIV/AIDS in Botswana. The target community consisted of mostly illiterate or functionally illiterate users who were not familiar with voice response systems, but were used to phones for purposes of communication. The sensitivity of the subject HIV/AIDS also brought up privacy issues that had a significant influence on the design process (Ndwe, 2009).

Focusing more on the cognitive aspects of the use of interactive interfaces, van Linden and Cremers (2008) studied how functional illiteracy affects the use of Automated Teller Machines (ATM) and presented a set of guidelines for designing ATMs that would be better suited to the needs of illiterate and functionally illiterate users (van Linden and Cremers, 2008; Cremers et al., 2008). Also aiming at a better understanding of the limitations and use of technology by target users from developing countries, Findlater et al. (2009) investigated the differences between the needs of illiterate, functionally illiterate and literate users, reaching the conclusion that they should be treated differently among themselves.

As the technological infrastructure for providing access to computing technologies is often lacking in developing areas, in some projects it was considered that mobile phones would serve the purpose of bridging the digital divide better than personal computers. Indeed, it is a known fact that mobiles are used extensively in the poorer countries: the cellular infrastructure is already available and devices are typically cheaper than a desktop computer. Built-in speakers and microphones also provide the possibility of using speech-based interfaces, taking advantage of the oral communication traditions commonly found in developing areas.

Medhi et al. (2009) investigated the usability of different existing mobile payment services in India, Kenya, the Philippines and South Africa. In a follow-up research, they compared the preferences and performance of illiterate and functionally illiterate users on three different prototypes for the same mobile payment service, one using a text-based design, the second one using a spoken dialogue without any text, and the third one using a text-free rich multimedia design. Also using mobile phones as platform, Frohlich et al. (2009) carried out a project that aimed to empower a rural community in India with the possibility of creating and sharing

non-textual information using a touch-screen camera-phone; the software to create the short audio-visual clips had an interface that was mainly icon-based.

Apart from interfaces that run on mobile phones, the devices themselves have also been subject of research by Lalji and Good (2008). The researchers tried to understand how interfaces of mobile phones can be better designed to serve the real needs of illiterate users effectively. The study was conducted in Mumbai, India, and although many of the characteristics of the prototype developed by the team were likely to be relevant only to the target community, the design process itself provided valuable insights on how to design interfaces for so-called non-traditional users.

This chapter discussed illiteracy, its relevance to research in technology for development and gave examples of what has been done by the HCI community to provide information systems and services to low-literacy users. The next chapter looks briefly into the User-Centred Design (UCD) approach, a design philosophy widely used by the HCI community, in which the work presented in this thesis is based.

4. User-Centred Design

The Human-Computer Interaction community has long recognised the importance of adopting a user-centred approach to design usable systems. Usability can be understood as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11, 1998). Other definitions of usability also include considerations about safety (Preece et al., 1994), learnability, memorability and error rates (Nielsen, 1993).

The term User-Centred Design (UCD) refers to a philosophy that can be employed to create usable software. Multi-discipline is at the core of UCD, as is the understanding that the life cycle of computer-based interactive systems must involve the user from the beginning until the end (Bainbridge, 2004).

One of the best known guides in implementing the User-Centred Design approach is ISO 13407 (ISO 13407, 1999). This International Standard is part of a significant effort that has been put into defining standards that support the design, development and evaluation of usable products (Bevan, 2009). It represents today a general reference model, without any recommendations for specific methods, aimed especially at project managers in charge of planning the software life cycle. It describes five main activities:

1. **Plan the human centred process:** The first step consists in creating a plan that specifies how the whole software development process will proceed and how it will include the other human-centred activities.
2. **Specify the context of use:** The context of use is the environment where the product will be used. It consists of users, tasks, organisational environment and physical environment.
3. **Specify user and organisational requirements:** After defining the context where the software will be used, the set of functional requirements of the software have to be clearly defined.
4. **Produce design solutions:** Based on the information gathered in the two previous activities, possible design solutions are produced. These solutions are to be iterated until a satisfactory solution is ready.

5. **Evaluate designs against user requirements:** The solution is evaluated against the relevant aspects as defined in the first stages.

After the planning phase, all the other four activities are carried out iteratively until all the requirements are met, as shown in Figure 1 below.

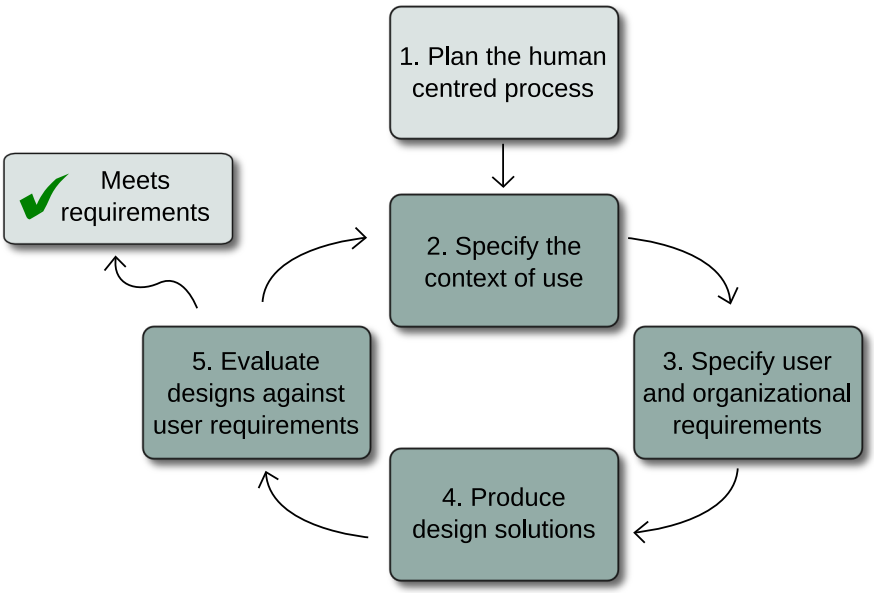

Figure 1: UCD process described by ISO 13407:1999.

The guidance available in ISO 13407 is complemented by the more technically oriented considerations made in ISO 9241, in particular in *Part 11: Guidance on usability*. As is the case with ISO 13407, this standard does not provide specific methods to be used; instead, it presents general principles. The main goal of ISO 9241-11 is to define usability, and to guide developers and those writing system requirements in specifying and evaluating the usability of a product.

The User-Centred Design process and the five activities defined in ISO 13407 serve as the basis for the analysis carried out throughout this thesis, and more specifically for the evaluation of methods presented in Chapter 8, *Evaluation of methods for designing at a distance*.

5. Methodology

The work presented in this thesis was performed using literature review as the main approach. This methodology was chosen because it provides a good overview on current practice and, in addition, allows for comparison between several views on similar problems.

This review was conducted on a set of recent conference papers[1], journal articles and presentations on ICT4D and development of user interfaces for low-literacy users. Searches in Google Scholar[2] using keywords such as "illiterate users", "illiteracy hci", "user interfaces low-literacy" and "ict4d user interfaces" provided an initial collection of relevant papers. References and citations found in those papers suggested who are the main contributors and which are the most important conferences in the field. The list of papers was expanded as other themes and keywords were identified and new searches were performed. The complete list of selected papers can be found in *Appendix A: Papers used in the review*.

The most relevant observations, conclusions and implications for design were highlighted from the papers and combined in a list of issues. Many papers addressed more than one issue at a time, and many issues were addressed in similar ways by different researchers. The next step was to group related issues under labels that described them briefly. A set of 29 topics, grouped in larger categories and subcategories, emerged from that list. The collected and categorised data is presented in Chapter 6, *Development of ICTs for low-literacy users in poor regions*.

Although comprehensive, the list of considerations mentioned above is too abstract and hard to be put to use. It was clear that something more succinct, with a practical application, was needed. As a very pragmatic part of the work of developing applications is choosing the methods to employ throughout the process, it was decided that a tool to guide researchers in this choice would be a useful contribution. For that end, a framework for analysis of methods was created.

The framework consists of ten questions, created from considerations on how the issues collected from the literature relate to each other and how they affect each

[1] The review was made in 2009, considering papers published since the year 2000. It was slightly updated in 2011.

[2] Available at *http://scholar.google.com*.

phase of the User-Centred Design development process. The questions are connected to several different issues, and some issues are referenced in more than one question. In addition, the questions raise issues that are relevant in the UCD process as a whole.

Once the first draft of the framework was ready, a set of methods from all five activities of the User-Centred Design process was selected to be evaluated, in order to confirm the validity of the framework and identify if any adaptations were needed. The set contained 23 methods that could support the development of applications for users who are geographically separated from the research team. An iterative process of refinement was performed, alternating the evaluation of methods and small changes in the questions, until the framework reached its final form.

The evaluation itself is also presented in this thesis, as it exemplifies the application of the framework in a concrete situation.

6. Development of ICTs for low-literacy users in poor regions

When developing systems for a non-traditional group of users, carefully putting the user at the centre of the process turns out to be not only important, but also very challenging. Most of the techniques developed so far by the HCI community have been created in the context of the developed world, and may not be readily applicable in groups of users such as the illiterate and functionally illiterate of the developing world (Kamppuri et al., 2006; Chetty and Grinter, 2007; Maunder et al., 2007).

In order to create a comprehensive overview on what the researcher will find while targeting low-literacy users, a set of considerations on the characteristics of the users, on the development process and recommendations for the final product were gathered from the literature. The following sections provide an overview of how the particularities of this user group and of their environment reflect in the end product and in the development process itself.

6.1 Cultural diversity

Cultural differences Exploring cultural differences is generally not very well supported by traditional HCI techniques. Deeply rooted cultural and social issues might be hard to explore and might have a significant impact in the success of the technology being designed (Bednarik et al., 2007; Maunder et al., 2007).

Sometimes, the introduction of a new information technology system in a community or organisation might change existing social relations (Dearden, 2008), which affects both the willingness of the community to help and the future acceptance of the system. These cultural issues might be unclear even to people who belong to the culture being studied; as a result, there is a high probability that these matters are not detected in interviews or even in field observations (Kamppuri et al., 2006). Political and economic settings are also relevant, and usually not easy to identify (Cockton, 2009).

Researchers and designers might have prejudices, make assumptions, rely on stereotypes or simply lack knowledge about target users and their culture, which

in turn may cause overlooking or misinterpretation of collected data (Rankin et al., 2009). There is also the risk of creating solutions that do not suit the intended users. Rachovides et al. (2007) illustrate well this last point in their account of the development of a digital story telling application, called StoryBank, aimed at poor communities in Bangalore, India. In a focus group session participants were asked to identify icons that would be used to represent story categories in the application. The icons were clip art images, based on Western culture references; as a result, participants did not recognise some of the icons. After some discussion, it became clear that icons should reflect the Indian rural lifestyle to be identifiable by those users.

There is also danger of unintended consequences of acts made in good faith simply by ignorance of local cultural norms (Dearden, 2009), or by big promises that never come true (Júdice and Júdice, 2007; Dearden, 2008). In addition, users can be very excited and appreciative that someone is paying attention to their needs and taking them seriously (Parikh et al., 2003; Cremers et al., 2008; Jones et al., 2008). While this is good for researchers and designers, who are likely to have community support in their project, it also increases the moral responsibility of the team towards the community.

Language barriers The language diversity in developing, non-western countries brings up many challenges related to that diversity (Dray et al., 2003). Language might be a difficult barrier, and the use of an interpreter has to be arranged and taken into account in the methodology used. Even when the language is the same, different backgrounds can cause misinterpretations (Tucker, 2004).

Learning about the community It is important to gather as much information as possible about the target community in advance. In addition, there is the need for an attitude of mutual learning and collaboration among all the parts involved, both during and after the project. This is essential for the sustainability of the project. (Dearden, 2008)

Unreliability of answers In the data collection phase, it is possible that the perceived higher socio-economic status of the researcher inhibits honest answers, for example inducing users to give positive feedback to please the researcher (Blake and

Tucker, 2006; Rachovides et al., 2007), making participants lie to present themselves more favourably to the outsiders (Cheng et al., 2008), or even making users suspicious of the purpose of the research, therefore causing participants to give incomplete or false answers (Thatcher et al., 2005; Sivakumar et al., 2006).

Usefulness and relevance The application must be useful and interesting to users, and relevant to their daily lives (Deo et al., 2004; Medhi et al., 2006; Jones et al., 2008; Lalji and Good, 2008; Frohlich et al., 2009). This is true for any group of users, be them experienced or novice, literate or illiterate. However, in the case of software for users in the developing world, usefulness is crucial for its acceptance and adoption, whereas adoption of software aimed at other user groups can be influenced by other factors as well, such as lack of other available options, company policies and training.

6.2 Environment

Comfort levels Researchers need to make the settings as comfortable as possible for the participants, as low-income users in developing regions are likely to have low self-esteem and are probably going to be apprehensive about the situation, about using technology and about the social distance between themselves and the researchers (Parikh et al., 2003; Medhi et al., 2006; Plauche et al., 2006; Dhakhwa et al., 2007; Taoufik et al., 2007; Cremers et al., 2008; Lalji and Good, 2008; Medhi et al., 2009). Suggested ways of creating a more comfortable setting for participants are: testing in familiar environments for the participants, instead of in laboratories (Medhi et al., 2006; Cremers et al., 2008); recruiting participants through contacts they trust (Medhi et al., 2006); keeping a familiar person present during the tests (Medhi et al., 2006); using paper and cardboard prototypes instead of real devices, to remove the fear of breaking something (Rachovides et al., 2007); using dramatised stories to present tasks and motivate the participants (Medhi et al., 2006); and allowing for the participant's privacy, in case the fact of being illiterate seems to be a reason of shame and discomfort for the participant (Cremers et al., 2008).

Difficulties in recruiting Illiteracy is highly related to low income and inflexible occupations, which might place restrictions on where and when participants are available for interviewing and testing. For example, Brewer et al. (2006) report that

recruiting illiterate participants in a telemedicine project in Tamil Nadu, India, took as much as six times the time required to recruit literate users for the same project.

Reluctance to participate in the studies might also be a problem in the recruiting phase (Plauche et al., 2006; Maunder et al., 2007). Getting in touch directly with the users is further complicated by the fact that normally there are no support groups or communities formed by illiterate and functionally illiterate people, who do not seek recognition of their condition, as opposed to other minorities such as the community of disabled users (Tambascia et al., 2008).

Distracting environments Applications developed for low-literacy users are likely to be used in distracting environments, possibly in public and noisy locations. Therefore, there is the need to pay special attention to the contextual cues in the navigation, to remind users where they are in the system in case they get distracted (Deo et al., 2004). In addition, it is also likely that the user research has to be done in such environments. This can impact, for example, the quality of collected data, the time required to perform the tests and the amount of participants that has to be recruited (Plauche et al., 2006).

Informed consent In experiments with human participants, researchers are supposed to obtain informed consent from all participants, making sure they understand the procedures of the experiment and taking care that the incentives offered are not too valuable that they become coercive to the participants. (Dearden, 2011)

Limited infrastructure Restrictions on the available infrastructure have a big impact on hardware requirements for the application or device, as it is important to consider the environment where the system will be used. Price, local availability and/or import taxes for equipment, resistance to eventual harsh climate conditions and even theft can affect the feasibility of the project and the sustainability of the system once it is deployed. Such limitations in infrastructure can also impact other phases of development, such as requirements gathering and testing, and have to be carefully considered in advance. (Baker et al., 2006; Brewer et al., 2006; Maunder et al., 2007)

Local partners Working in collaboration with local partners is a good way to minimise the impact of difficulties caused by cultural distance between the research

team and the community (Dray et al., 2003; Baker et al., 2006; Brewer et al., 2006; Plauche et al., 2006; Dearden, 2008; Toyama, 2010). Blake and Tucker (2006) suggest the adoption of what they call a "community-centred approach", where the team engages a wider community, consisting of "human access points" such as local non-governmental organisations (NGOs), local researchers, other professionals working with the target group, and so forth, especially in the initial phases of the project. By involving more people besides the intended user group, it is easier to better understand the social dynamics in the target region.

6.3 User characteristics

Illiterate brain Research has indicated that there are differences in the way that an illiterate person's brain functions, in comparison to a literate person's one. For instance, van Linden and Cremers (2008), based on the results of cognitive tests, argue that "compared to literate individuals, functionally illiterate persons are less proficient in the processing of spoken information, have a lower ability to understand and follow-up instructions, have a lower cognitive processing speed, have lower visual memory and visual organisational skills, have lower mental spatial orientation skills, demonstrate a lower ability to keep their attention focused on a task and have more difficulty to divide attention". The results acquired by van Linden and Cremers are supported by previous research in neuroscience, which indicates that the functional architecture of an adult brain is influenced by learning to read and write during childhood (Petersson et al., 2000).

Illiteracy *versus* functional illiteracy Most systems designed for low-literacy users fail to distinguish between illiterate and functionally illiterate users, even though there is an indication that they are, in fact, different groups with different needs. This was well demonstrated by Findlater et al. (2009) in an experiment with illiterate and functionally illiterate participants. The main task of the experiment required users to listen to words in the Kannada language and search for them among a set of 40 different words, presented in written form with an audio button on the side. Participants could then use different strategies to complete the task: visual search, audio search or a combination of the two. Results showed that although functionally illiterate users do have difficulties with text-only interfaces, they benefit from a text-based interface augmented with audio. Fully illiterate users, on the other hand, do not.

One of the benefits that audio augmented interfaces can have for functionally illiterate users is to support written language acquisition, stimulating the maintenance of the existing rudimentary reading skills by incidental learning and generally encouraging literacy (Huenerfauth, 2002a; Plauche et al., 2006; Findlater et al., 2009).

Another advantage for this user group is the use of simple text captions as accelerators. With this feature, it is possible to provide to functionally illiterate users a much faster interaction when compared to speech-only based systems: returning users are likely to recognise options and jump ahead to select them, without the need to wait for all the options to be read aloud (Huenerfauth, 2002a).

Illiterate users have their own needs and preferences and consequently it is recommended to consider them as a different target group during the development. Research indicates that, as opposed to functionally illiterate users, fully illiterate users strongly prefer text-free or minimal-text interfaces (Medhi et al., 2006; Findlater et al., 2009).

Inexperience with technology Users from low-income regions are likely to be less familiar with technology. This characteristic might demand adaptations in the protocols of the evaluation and in the tasks, as well as in the design itself (Dray et al., 2003). Even the nature of a usability test might be easily misunderstood by the participants, thus bringing unexpected behaviour (Brewer et al., 2006). It has also been reported that users can be very confused about the nature and purposes of prototypes, requiring more time and care in the explanations before the tests (Parikh et al., 2003; Lalji and Good, 2008).

Need of help Illiterate people often count on the help from a literate person, usually a neighbour or a family member, to cope with daily tasks that require reading and writing (Parikh et al., 2003; Dhakhwa et al., 2007; Cremers et al., 2008; Filgueiras et al., 2009). Reddy (2004) recognises the value of the local person who is available to help the community— the "local expert" or "Village Information Officer"[3]—and suggests that, in order to achieve success in a project for illiterate users, providing training for the local expert is essential. Counting on the help of such local experts can be valuable also during the testing phase.

[3]Note that local experts are not the same as local partners, described earlier in this chapter. Local partners are entities, organisations or universities that can offer qualified help during one or more phases of the project. Local experts, on the other hand, are members of the community.

Work in groups One striking characteristic of illiterate and functionally illiterate users is their preference towards working in groups. Many researchers noted that low-literacy users seem more confident during group activities, where they can get help and reassurance from their peers while interacting with the computer (Medhi et al., 2006; Rachovides et al., 2007; Cremers et al., 2008). In addition, these users seem eager to share their knowledge with the group. While deploying and informally testing an information kiosk, Taoufik et al. (2007) observed that, after successfully using the system, low-literacy users were keen on staying around and helping others. Jones et al. (2008) noted that their story-telling application instigated users to come back at a later time bringing others, to show any interesting content previously found.

6.4 Recommendations for design

6.4.1 Application design

Building up confidence For dealing with users who have low levels of education, software can play an important part in providing opportunities for learning. Furthermore, using strategies that allow for progressive learning can be valuable to assist users in interacting with software. Lalji and Good (2008) employed the learner-centred design (LCD) philosophy, described by Soloway et al. (1996), in the development of a mobile phone interface for illiterate users. The LCD approach intends to support the needs of learners—growth, diversity, and motivation—by incorporating learning supports, or *scaffolding*, in the application design, guiding users through tasks that would be too complex for them to perform without any help.

In addition to the scaffolding technique, Lalji and Good also applied the *training wheels* approach, described by Carroll and Carrithers (1984), and *multi-layer interfaces*, outlined by Shneiderman (2002). The *training wheels* approach consists in designing interfaces in a way that only the most basic and simple functions of the software are available for beginners, while the advanced functions are hidden at first. This way, new users are less likely to get frustrated and may even learn to use the interface faster. *Multi-layer interfaces* have a similar concept: the interface has different sets of functions that are available at one time, in a way that complexity is increased little by little. Once users master the functions available in one layer, they can move on to a higher layer.

The support provided by the learner-centred design approach is especially important for users with low-literacy and limited computer experience, as this group is much more likely to suffer from anxieties and frustrations when using technology than their literate counterparts.

Simplicity in design Because of low levels of formal education and computer experience, illiterate and functionally illiterate users need the interface to be extremely simple, with the tasks that are available at one time reduced to the minimum. A simple design improves ease of learning and ease of remembrance, both of which are important requirements for this user group. (Martins et al., 2003; Parikh et al., 2003; Deo et al., 2004; Reddy, 2004; Taoufik et al., 2007)

6.4.2 Language and metaphors

Appropriate language The system has to be developed in the dialect spoken by its intended users, and not in the official variation of the language. This is important even for text-based interfaces and even if it is believed that users would not understand written text. Using the local language and local references and images encourages identification with the system, building trust and giving users a sense of ownership. (Parikh et al., 2003, 2006; Taoufik et al., 2007; Lalji and Good, 2008)

Appropriate metaphors It is important to consider carefully and thoroughly the use of hardware and Graphical User Interface (GUI) concepts and metaphors when developing software for users who are unfamiliar with technology. Concepts that are considered normal by experienced users—scroll bars, context menus, hierarchical navigation, and in some cases even keyboard and mouse—can be problematic for novices, especially low-literacy users (Parikh et al., 2003; Deo et al., 2004; Jones et al., 2008; Medhi et al., 2009).

Low-literacy users are more likely to understand metaphors based on familiar concepts, taken from their everyday life. One good example is the use of paper-based interfaces that allow users to enter data in paper and transfer that information to the system with the use of different technologies such as Optical Character Recognition (OCR), mobile cameras, bar codes or Radio-Frequency Identification (RFID) (Parikh et al., 2003; Medhi et al., 2006; Parikh et al., 2006).

6.4.3 Graphical interface

Colours and shapes It has been reported that colours, especially reds and yellows, can be successfully used to draw attention to relevant parts of applications aimed at low-literacy users (Parikh et al., 2003; Plauche et al., 2006; Taoufik et al., 2007). Using colours to aid navigation, however, might cause confusion in case similar colours are used, for example green and blue (Lalji and Good, 2008). Buttons of different shapes can also help users distinguish between available options in the interface (Huenerfauth, 2002a).

Graphics style With regard to the graphics style used in non-textual interfaces, it was identified that it is necessary to find a balance between abstraction and photorealism. Too much abstraction can be difficult to interpret, but, on the other hand, photographs and drawings with too much information can also be confusing. This happens because photographs or photo-realistic drawings most of the time include elements that are not relevant to the task at hand. (Martins et al., 2003; Medhi et al., 2007)

In addition, pictures and drawings have to be used taking into consideration that users from different cultures or with different religious backgrounds can interpret graphics differently (Medhi et al., 2006).

Geographic navigation For map-based applications or interfaces that require geographic navigation, Medhi et al. (2006) recommend using landmarks as references. Street names, full addresses and absolute directions (north, east, south-west, etc.) are not well understood. This recommendation is reinforced by subsequent findings, which indicate that low-literacy users have problems reading maps and finding their ways in unfamiliar environments (Cremers et al., 2008).

Dynamic text highlighting When providing voice feedback in the interface, it has been noted that it is useful to highlight visually which portions of the screen or text are being read and what needs to be clicked. This improves the ease of use and also serves the goal of supporting reading acquisition. (Huenerfauth, 2002a; Taoufik et al., 2007; Findlater et al., 2009)

Use of numbers Basic literacy tests show that an illiterate person is usually able to remember and manipulate numbers (Ghosh et al., 2003; Parikh et al., 2003;

Medhi et al., 2009). To take advantage of this, some researchers have attempted to use numbers in interfaces for users with low literacy skills. However, although numeric data (tables, calendars, phone numbers, etc.) is usually well understood, low-literacy users have difficulties with the use of numbers as navigation or to represent hierarchies (Ghosh et al., 2003; Parikh et al., 2003). Numbers are better used in contexts that are already familiar to the user.

6.4.4 Interaction with the application

Multimodal interfaces Research indicates that additional input and output modalities in the software benefit low-literacy users significantly. The extra cues provided by additional output modalities (photos, animations, videos, sounds, speech, etc.) make it easier for users to understand the information provided by the application. The combination of different input modalities (keyboard, mouse, touch, speech recognition, cameras, etc.) can provide a more natural interaction, and redundancy can lower error rates. (Reddy, 2004; Medhi et al., 2006; Plauche et al., 2006; Taoufik et al., 2007; Medhi et al., 2009)

Physical interaction Parikh et al. (2006) noted that low-literacy users might have problems with fine motor control, resulting in difficulties with the mouse and with small keypads in mobile phones. Anxiety towards being tested, using unfamiliar technology and fear of breaking an expensive device are likely causes of such difficulties. Although this can happen to anyone, low-literacy users from poor regions are more likely to be affected because of their unfamiliarity with technology and fear of having to pay for eventual damaged caused by them.

Speech interfaces Because of the strong oral traditions that exist in rural areas in developing countries, speech interfaces are seen as a good way of providing universal access to illiterate users (Plauche et al., 2006; Dhakhwa et al., 2007; Neerincx et al., 2009). Medhi et al. (2009) identified that spoken dialogue systems are used with less need for assistance and the speed of the interaction is faster when compared to systems with rich multimedia interfaces.

Nevertheless, the difficulties associated with developing systems using speech interaction, especially speech recognition, are even more problematic in developing

countries, mainly because of the linguistic, dialectal and cultural diversity in those regions. There is low availability of linguistic resources to allow for the development of good voice recognition systems, and the cost of development is very high (Plauche et al., 2006; Alvarez, 2008).

There is also a technical limitation in the use of voice output in the design: synthesised speech does not sound natural enough yet. For illiterate users, the robot-like pronunciation can be especially confusing. As a result, pre-recorded voice clips are preferred to synthesised speech. However, that can be a limitation for software developers, and it has a significant impact on the cost of development as well. (Deo et al., 2004; Taoufik et al., 2007)

Take away information In richer regions of the world, it is common that computers and mobile phones are devices used by a single person. In poorer regions, particularly in rural areas in the developing world, it is much more common that computers are made available for shared use in public spaces, in the form of information kiosks and telecentres, and mobile phones are usually shared among family, close friends and even neighbours. Consequently, it is important to remember that users might need to take away with them the information presented by the device, for example by printing it or storing it on removable media. (Huenerfauth, 2002a; Taoufik et al., 2007)

7. Framework for analysis of UCD methods

Chapter 6, *Development of ICTs for low-literacy users in poor regions*, gave an overview of issues that should be considered when developing applications and devices for low-literacy users in developing countries. They are summarised here as a framework for analysis, presented in Table 3 and further explained in the rest of this chapter.

#	Questions
1	Does the method encourage the development of software that is useful and relevant to target users and sustainable in the long term? [**Relevance and sustainability**]
2	Does the method support and encourage participation of local partners in the process, including planning, recruiting users and performing tests? [**Local partners**]
3	Does the method support exploring, understanding and managing cultural differences and language barriers between researchers and target users? [**Cultural and language differences**]
4	Does the method provide users with a physically and psychologically comfortable environment, to ensure informed participation and reliable answers? [**Comfortable environment**]
5	Does the method recognise and support exploring the users' particular characteristics and needs, related to illiteracy? [**User characteristics**]
6	Does the method take into consideration users' needs for simplicity and support for progressive learning? [**Simplicity and support for learning**]
7	Does the method encourage using appropriate metaphors and language in communication with the users and in the design itself? [**Appropriate language and metaphors**]
8	Does the method support appropriate investigation of suitable graphical user interface characteristics, so that the needs of low-literacy users are properly met? [**GUI characteristics**]
9	Does the method support appropriate investigation of interaction modalities and device characteristics, so that the needs of low-literacy users are properly met? [**Input and output modalities**]
10	Does the method take into consideration characteristics of the environment and possible infrastructure limitations? [**Limitations in infrastructure**]

Table 3: Framework for analysis: summary table

All ten questions can potentially be applied to methods pertaining to all activities of the User-Centred Design process. This will be discussed individually for each

question, and also in the next chapter, where the application of this framework in a specific set of User-Centred Design methods is exemplified.

The discussion below employs the labels presented in Chapter 6, in order to demonstrate the connection between the considerations examined in that chapter and the questions proposed here. Table 4 (p. 36) summarises that relationship.

1. Does the method encourage the development of software that is useful and relevant to target users and sustainable in the long term?

This question is especially relevant in methods that are applied in earlier phases of development. By considering carefully and from the very beginning the potential impacts of infrastructure limitations, cultural differences and characteristics of the local context, including matters that are harder to identify, it is more likely that the end product is in fact useful to its intended users and to the community.
Related issues: Cultural differences, Usefulness and relevance, Limited infrastructure

2. Does the method support and encourage participation of local partners in the process, including planning, recruiting users and performing tests?

Because the local context is usually so distant from the reality of researchers, collaboration with local partners is a highly recommended way of making sure that political, economic and cultural issues are not unintentionally disregarded. Local partners can also be very helpful in overcoming difficulties in accessing and recruiting local users.
Related issues: Difficulties in recruiting, Local partners

3. Does the method support exploring, understanding and managing cultural differences and language barriers between researchers and target users?

Some methods are more effective at looking at the local context of users than others. Sometimes, traditional ways of investigating the context can be useful in identifying more subtle issues, provided that researchers are aware of the possible pitfalls in advance and look for ways of minimising that risk. Language barriers can also be a problem, even considering regional and social differences within the same

language. It is important to identify how to effectively communicate with users, using language that they understand and feel comfortable with, and using references that are familiar to them.
Related issues: Cultural differences, Language barriers, Learning about the community, Appropriate language

4. Does the method provide users with a physically and psychologically comfortable environment, to ensure informed participation and reliable answers?

The research team must always take participants' well-being into consideration. They have to be aware of any social or power distance, perceived or real, between them and end users, as it may create situations where users feel like they have to behave in a certain way to please researchers, for example refraining from making negative remarks or accepting to participate in tests against their will. Taking users to research facilities and using too formal language can be intimidating to people from marginalised communities, and should be avoided. It is preferable to conduct tests and interviews in their own environment and to use cultural references and metaphors that are familiar to them.
Related issues: Unreliability of answers, Comfort levels, Informed consent, Appropriate language

5. Does the method recognise and support exploring the users' particular characteristics and needs, related to illiteracy?

Specific characteristics of low-literacy users impact all phases of development, especially the design and the testing phases. The way that low-literacy users process information is different, and that affects not only the end product but also how users' involvement in the research can happen. In addition, researchers may need to adapt procedures and protocols to low-literacy users' characteristics such as preference for working in groups, reliance on the help from a literate person and inexperience with technology. Finally, illiterate and functionally illiterate users have different needs and characteristics, and should be treated as different user groups.
Related issues: Illiterate brain, Illiteracy vs functional illiteracy, Inexperience with technology, Need of help, Work in groups

6. Does the method take into consideration users' needs for simplicity and support for progressive learning?

Low-literacy users need to interact with interfaces that are simple and easy to learn, especially because usually this user group has little or no familiarity with technology. This applies not only to the end product, but also to any experimental research software that the research team might employ during the development. The concept might even be extended to other activities, not necessarily involving devices or applications: any task that participants are required to do must be as simple as possible, and, if need be, complexity has to be increased gradually.
Related issues: Comfort levels, Building up confidence, Simplicity in design

7. Does the method encourage using appropriate metaphors and language in communication with the users and in the design itself?

Researchers must employ metaphors that make sense in the user's world and they must always use the local language, in the variation spoken by that community. This is important not only in the end product, but also in all interactions with users, *e.g.* during interviews, surveys, experiments and usability tests. Researchers must speak with users in a way that they understand and with which they feel comfortable.
Related issues: Comfort levels, Appropriate language, Appropriate metaphors

8. Does the method support appropriate investigation of suitable graphical user interface characteristics, so that the needs of low-literacy users are properly met?

In previous research, many recommendations have been made concerning graphical user interface characteristics, such as the use of numbers in the interface, the use of colours and shapes, the level of abstraction or photorealism that should be used in graphics, how to highlight areas in the interface, especially text, how to present geographic navigation, among others. For each project or research question, there will be different issues to consider. The method should provide the means to explore and investigate possibilities with an open mind, as the answer to what is best for those users might be something completely new and different from known ways of implementing user interfaces—especially because low-literacy users' inexperience with technology might call for completely different solutions than those normally found in applications and devices aimed at other user groups.

Related issues: Inexperience with technology, Colours and shapes, Graphics style, Geographic navigation, Dynamic text highlighting, Use of numbers

9. Does the method support appropriate investigation of interaction modalities and device characteristics, so that the needs of low-literacy users are properly met?

The method should foster appropriate and open-minded investigation of how the interaction with the application or device should happen. Many factors influence both the suitable characteristics of the end product and how usability tests should be performed. For example, usability tests carried out in laboratories do not reflect how interaction happens in the real context of low-literacy users, where there might be interruptions, connectivity problems and many people using a single device at once, among other issues.
Related issues: Distracting environments, Limited infrastructure, Inexperience with technology, Work in groups, Multimodal interfaces, Physical interaction, Speech interfaces

10. Does the method take into consideration characteristics of the environment and possible infrastructure limitations?

Limitations in infrastructure and the environment characteristics may have a significant impact both during the testing phase and in collecting use requirements. For example, public and noisy environments affect how interaction with users happens during tests. In the same fashion, infrastructure limitations and the circumstances of use affect the design of any application or device targeted at users in developing regions. Shared used of devices and computers create the need to properly support users' need to take away with them relevant information presented by the device.
Related issues: Learning about the community, Distracting environment, Limited infrastructure, Take away information

			Framework questions									
			1	2	3	4	5	6	7	8	9	10
			Relevance and sustainability	Local partners	Cultural and language differences	Comfortable environment	User characteristics	Simplicity and support for learning	Appropriate language and metaphors	GUI characteristics	Input and modalities	Limitations in infrastructure
Cultural diversity		Cultural differences	•		•							
		Language barriers			•							
		Learning about the community			•							•
		Unreliability of answers				•						
		Usefulness and relevance	•									
Environment		Comfort levels				•		•	•			
		Difficulties in recruiting		•								
		Distracting environments									•	•
		Informed consent				•						
		Limited infrastructure	•								•	•
		Local partners		•								
User characteristics		Illiterate brain					•					
		Illiteracy vs functional illiteracy					•					
		Inexperience with technology					•			•	•	
		Need of help					•					
		Work in groups					•				•	
Recommendations for design	**Application design**	Building up confidence						•				
		Simplicity in design						•				
	Language and metaphors	Appropriate language			•	•			•			
		Appropriate metaphors							•			
	Graphical interface	Colours and shapes								•		
		Graphics style								•		
		Geographic navigation								•		
		Dynamic text highlighting								•		
		Use of numbers								•		
	Interaction with the application	Multimodal interfaces									•	
		Physical interaction									•	
		Speech interfaces									•	
		Take away information										•

Table 4: Considerations on the development for low-literacy users in poor regions *versus* framework questions

8. Evaluation of methods for designing at a distance

The previous chapter presented a framework that serves as a tool to evaluate User-Centred Design methods against their suitability for producing applications and devices for low-literacy users in the developing world. By using the framework to guide their choices, researchers can identify in advance possible pitfalls or weaknesses of their strategies, gaining a more complete understanding of what are the possible approaches and their downsides, and what can be done to avoid or minimise problems related to each chosen method.

Now, to exemplify its application, the framework is used to evaluate a number of methods from all five activities of the User-Centred Design process. The set of methods have been chosen with one specific situation in mind: methods that could support the development of applications for users with low-literacy skills in the developing world, when those users are geographically separated from the research team.

Designing at a distance is understood here as a situation where the main researcher or developer conducts the process from a different location, possibly a different country, than the community of users. It does not imply doing everything at a distance, as this can be effectively impossible, especially when dealing with low-literacy users. The help of local organisations, institutions or universities is, as will be demonstrated in this chapter, very important, and they can have more or less participation in the process depending on the situation.

The distance between the research team and the context where the application will be used brings very specific challenges, which in turn increase the complexity of an already complicated situation. For a team that has to face limited access to their users, extra attention has to be paid to properly plan the development process.

Only a few methods can be successfully applied at a distance, and most of them allow for little or no contact at all with the end user. The potential of overlooking relevant issues increases in this situation. And this is where the framework proposed in this thesis can be helpful. Used as a checklist, it can guide researchers in making

informed choices about which methods to choose and what has to be taken into consideration when applying those methods in the development of applications for low-literacy users in the developing world.

Table 5 shows the set of methods that have been selected for analysis, considering the possible application of the methods at a distance. Most of the methods are described and classified according to the works by Maguire (2001) and Bevan (2003). In addition, four other methods, which have been previously applied in the context of developing applications for low-literacy users, have been included in the discussion: *Design probes* (Mattelmäki, 2006; Júdice and Júdice, 2007), *Hypothetical User Design Scenarios* (Huenerfauth, 2002b), *Delegating tasks to the community* (Alvarez, 2008) and *Usability testing with similar users* (Deo et al., 2004).

Planning	**Context of use**	**Requirements**	**Design**	**Evaluation**
Usability planning and scoping	Identify and analyse stakeholders	Requirements meeting	Brainstorming	Heuristic evaluation
Usability cost-benefit analysis	Context of use analysis	User cost-benefit analysis	Parallel design	Satisfaction questionnaires
	User survey	Task analysis	Design guidelines and standards	Usability testing at a distance
	Design probes	Scenarios of use	Interface design patterns	Usability testing with similar users
		Personas	Paper prototypes	
		Hypothetical User Design Scenarios	Storyboards	
			Delegating tasks to community	

Table 5: User-Centred Design methods selected for analysis

In order to exemplify the application of the framework on a relatively large set of data, the evaluation is presented in a compact format, as a matrix evaluating each method according to each of the questions of the framework. The resulting analysis is shown in Table 7. For clarity and easier referencing, that information is split in

Tables 8, 9, 10, 12 and 13, which are placed before the more detailed discussion of the evaluation of methods in each of the five UCD development phases.

The evaluation consists on three possible answers to the questions of the framework (Table 3), which are coded as follows:

Symbol	Meaning
■	Yes, without any need for adaptations in the method.
□	Yes, provided that some adaptations are made.
×	No.
[empty]	Does not apply.

Table 6: Symbols used in the evaluation of methods according to the framework

The *full square* indicates that the method satisfies the needs identified by the question, without any further adaptation. For example, using *Design probes* is evaluated with a full square in question 4 (see Table 7) because it does not take users away from their surroundings, and as such it is a method that provides a psychologically comfortable environment for them. The method is also evaluated with a full square in question 3 because it can be very effective in giving insights on the cultural differences between users and researchers.

The *empty square* points out that the concerns indicated in the question will not be properly addressed unless researchers and developers make one or more adaptations in the method. The empty square symbol can also indicate that extra attention to "hidden" issues may be needed—that is, it may be necessary to take a step back and think about alternative ways of employing the method, ways that may not be immediately obvious to HCI practitioners used to working with western users. To illustrate this mark, one can look at the evaluation of *User surveys* in question 4: surveys and questionnaires are usually applied in written form, but have to be adapted to an oral format as to not embarrass or distress illiterate and functionally illiterate users.

The *"X"* symbolises that the method does not satisfy the needs identified by the question. For instance, the *Heuristic evaluation* method receives the X mark for question 2, indicating that it does not encourage the participation of local partners, as it is performed exclusively by usability experts using a predefined set of heuristics.

		Framework questions									
Phase	**Method**	**[1] Relevance and sustainability**	**[2] Local partners**	**[3] Cultural and language differences**	**[4] Comfortable environment**	**[5] User characteristics**	**[6] Simplicity and support for learning**	**[7] Appropriate language and metaphors**	**[8] Appropriate investigation of GUI characteristics**	**[9] Appropriate investigation of modalities**	**[10] Limitations in infrastructure**
Planning	Usability planning and scoping	■	□	□	□						□
	Usability cost-benefit analysis	■	×								
Context of use	Identify and analyse stakeholders	■	□	□		■					
	Context of use analysis		□	□		□					■
	User surveys	■	■	×	□	□		□			
	Design probes		■	■	■	□	□	□			
Requirements	Requirements meeting		□	×	×	□		□	□	□	□
	User cost-benefit analysis	■	□								
	Task analysis		□	×		□		□	□	□	
	Scenarios of use		□	□		□		□	□	□	
	Personas		□	□		□		□	□	□	
	HUDS		□	■		■			□	□	■
Design	Brainstorming					□	□	□	□	□	□
	Parallel design					□	□	□	□	□	□
	Design guidelines and Standards		×	×		×	□	□	□	□	□
	Interface design patterns		×	×		×	□	□	□	□	□
	Paper prototypes		□	□	■	■	□	□	□	□	■
	Storyboards		□	□	■	■	□	□	□	□	■
	Delegating tasks to community	■	■	■	□	□	□	□			□
Evaluation	Heuristic evaluation		×	■		×					
	Satisfaction questionnaires		□	×	×	□		□	□	□	
	Usability evaluation at a distance		□	×	×		□	□	■	■	□
	Usability testing with similar users		□	□	□	□		□	□	□	

Table 7: UCD methods evaluated against the framework

Finally, an *empty cell* points out that the needs identified by the question are not relevant to the method being evaluated, mostly because the method and the question relate to different phases of the development. Most of the non-applicable questions are fairly obvious and will not be discussed in detail, as the indications in Table 7 are considered sufficient to this evaluation. For instance, when delineating a usability plan, it is not necessary to consider the investigation of graphical user interfaces or input and output modalities; consequently, the method *Usability planning and scoping* does not receive any marks for questions 8 and 9.

The symbols described above can be interpreted as recommendations for use of a given method. Having more full squares does not necessarily imply that the method is better than the ones evaluated with more empty squares, but it does indicate that the method is likely to be more successfully applied with low-literacy users. Empty squares indicate methods that have the potential to work well, but researchers need to be more careful and aware of the particular characteristics and needs of the users in order to achieve good and valid results. The "X" symbol, on the other hand, indicates that the need identified by the question will not be satisfied; consequently, if the research team decides to apply the method nevertheless, it is necessary to use complementary approaches to make sure that the issues identified in the question are properly considered in the project.

The following sections discuss in more detail, for each phase of the UCD approach, the evaluation summarised in Table 7.

8.1 Planning

The first set of activities identified in the Human-Centred Design approach, **Plan the human centred process**, refers to the need for properly planning the whole process so that the development process is really focused on the user. This is even more relevant when researchers have limited access to their users, as time and money are likely to be scarcer and a good and complete plan may be the only way to move the project forward.

This phase is the most important for considering and planning the involvement of local partners, such as NGOs, government agencies or even researchers from local

universities. In addition, it is a good time to outline not only how the application will be developed, but also how the end product will be deployed, when the follow-ups will be made and how the team will support the post-release phase. In other words, how will it be ensured that the project is sustainable and effectively improves the lives of people from the local community.

	Framework questions									
Methods	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Usability planning and scoping	■	□	□	□						□
Usability cost-benefit analysis	■	×								

Table 8: Evaluation of methods for the planning phase

The method *Usability planning and scoping* provides a way for managing all usability-related activities in a project and defining how these activities relate to the other phases of software development, while *Usability cost-benefit analysis* addresses the financial benefits of investing in a user-centred design approach and avoiding unnecessary work and future redesign efforts.

As illustrated in Table 8, defining a consistent and well justified usability plan is of high importance to the relevance and sustainability of the project, but when developing for low-literacy users in the developing world, the plan has to give a much higher importance to considerations on the impact of cultural and language differences and of the characteristics of the local context on the process. This is also the appropriate moment to define how to involve users in a way that ensures that they are comfortable with the process, and also how to deal with possible limitations in infrastructure during the whole process.

Defining a usability plan typically does not involve third parties directly, but considering that taking all the relevant issues into consideration might pose a challenge to a research team that is not completely familiar with the local context, it is recommended that the usability plan is made with a higher involvement of local partners, if possible. The team must be aware that this involvement may require more time and eventually more money as well, but the benefits in the longer term justify the investment.

The elaboration of a usability cost-benefit analysis is of great importance to encourage the development of useful and relevant software, assuming that it justifies

financially all the usability efforts that will be carried out during the project and ensures that important steps are not omitted. This analysis does not involve local partners because it is a technical document that needs to be made by experts. In this method, it is not necessary to consider directly cultural differences, characteristics of users and of the environment, and even less so the characteristics of the end product. Some of these particular issues are not relevant for the usability planning and scoping method as well, as in this initial phase the focus is in how the investigation will happen and what can be done to ensure that the process is really centred in the user.

8.2 Context of use

The **Specify the context of use** phase of the development cycle is critical when developing applications for low-literacy users in developing countries, especially when the research team has little or no access to the local context. It is during this phase that researchers have the opportunity to understand the local context and also the cultural differences between themselves and the target community. If the methods chosen during this phase do not provide sufficient, accurate and unbiased information, all the subsequent phases will be affected. This, of course, happens also in projects for any other user group, but then the designers' intuition and educated guesses are based on a shared cultural and social ground. However, when the target users are so different from the research team, working with little or inaccurate information can result in software that simply does not meet users' needs. And considering the difficulties of accessing users in the developing regions, the cost of redesign is also much higher.

As it will become evident in the next paragraphs, involving local partners during this phase provides invaluable help in collecting accurate information regarding the context in which the application or device will be used. Local partners can help the team identify all stakeholders, not only the most common and obvious ones, and to properly explore users characteristics and needs. Additionally, in some cases, especially when designing at a distance, it is even impossible to gain access to certain communities without the aid of the local community.

Identify and analyse stakeholders, when performed properly, allows a broad exploration of all the parties that are going to be somehow affected by the system

	Framework questions									
Methods	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Identify and analyse stakeholders	■	□	□		■					
Context of use analysis		□	□		□					■
User survey	■	■	×	□	□		□			
Design probes		■	■	■	□	□	□			

Table 9: Evaluation of methods for defining the context of use

and their specific characteristics and needs. But in the case of low-literacy users, this analysis requires the adoption of a very broad understanding of the term stakeholders, to include less obvious groups, such as family members, neighbours, NGOs, etc., as illiterate user groups often need help from a literate person when using applications and devices.

Context of use analysis, a meeting with stakeholders with the objective of gathering information about users, tasks, the environment and the technology to be used, poses the risk of a biased or incomplete analysis in case not all stakeholders are heard. Uncovered issues might remain unnoticed until very late in the development process, causing unforeseen redevelopment costs or even the failure of the project.

User survey is a method that, in its usual application, employs questionnaires composed mainly of close-ended questions, applied preferably to a large number of users by mail, via the internet or even by phone. A survey can provide answers to a set of specific questions or uncertainties that have already been raised in other phases of the design, and, when well formulated, can give valuable information regarding what is important and relevant to users. Nevertheless, user surveys must be used with great care. The potential for problems with this method is high. Firstly, surveys created from the point of view of the researchers will probably give very little useful information regarding the specific characteristics of the user group. Secondly, users can have difficulties in responding to the questionnaire, especially if the survey is presented in a written format or in a formal language. Finally, low-literacy users usually get suspicious about answering questions to people that are perceived to be of a higher social class than themselves. A solution is to have local partners apply the questionnaires in person, in an interview-like format, to reduce resistance and to ensure that appropriate language and terms are used.

Design probes (also *cultural probes*) are methods that promote user participation in the development process by means of self-documentation, inspired by a set of assignments through which users can express their thoughts, feelings, ideas and experiences (Mattelmäki, 2006). Probes are usually provided by the design team to a group of users as a package that is left behind and later collected and analysed. It may include blank postcards, cameras, notebooks, voice recorders, among other items, that try to inspire users and prompt them to record their experiences and thoughts. It is a "non-invasive" method that allows for exploration of the cultural context of the participants in their own environment.

Júdice and Júdice (2007) describe the successful application of design probes in the development of a health care information system for marginalised functionally illiterate communities in Brazilian slums, in a study carried out at a distance. The authors highlight how local partners, in this case health care project workers, were important as the bridge between researchers and the target community. Their help was important to make it possible to recruit participants and to administer the probes, but also to gain the trust of the participants, as the social workers would not be seen as in a higher social position. In addition, the researchers point out the necessity to adapt the format of the probes previously described by Gaver et al. (1999) and Mattelmäki (2006), simplifying the instructions, adding graphics and local cultural references, to compensate for the low literacy skills of the participants.

The evaluation presented in this section indicates that current UCD methods give appropriate support to the **Specify the context of use** phase when designing-at-a-distance for low-literacy users. It is possible to observe that the involvement of local partners is mandatory in some cases, as it would be impossible to apply user surveys or design probes without the help of the community. Nevertheless, the amount of empty squares in Table 9 indicates that, although the four methods evaluated here can be applied at a distance for illiterate and functionally illiterate users, it is very important to seek guidance, either from the literature or from local partners, in order to avoid overlooking important issues; simply reproducing the usual way of employing those methods may render unsatisfactory results.

8.3 Requirements

During the **Specify user and organisational requirements** phase, methods focus on identifying which characteristics the end product will have to possess, in order to fulfil the objectives of the project, from the perspective of the end user. This is the phase when the information collected previously is consolidated into functional requirements that will guide the next steps of the process. The evaluation of how methods for gathering requirements fit into the situation of developing applications for low-literacy users highlights well the necessity of considering carefully the information collected about the target community, always cross-checking and validating the assumptions made, in order to properly support the needs of the user group regarding language use, GUI characteristics and input/output modalities.

	Framework questions									
Methods	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Requirements meeting		□	×	×	□		□	□	□	□
User cost-benefit analysis	■	□								
Task analysis		□	×		□		□	□	□	
Scenarios of use		□	□		□		□	□	□	
Personas		□	□		□		□	□	□	
Hypothetical User Design Scenarios		□	■		■			□	□	■

Table 10: Evaluation of methods for defining user and organisational requirements

A *Requirements meeting* has representatives of each of the stakeholders groups and also a representative of the developers. The goal is to identify usability requirements and to define ways of testing those requirements at a later stage. However, for users with low-literacy skills in developing regions, a meeting with researchers and developers may prove to be a very stressful and uncomfortable experience, considering the perceived social distance between the groups. In addition, cultural differences and language barriers are likely to provide a big challenge in communication. Considering the application of this method at a distance (a meeting held over the phone, video conferencing or other similar technology), the impact of limitations of infrastructure has to be taken into consideration.

With a *User cost-benefit analysis*, the research team tries to identify, for each stakeholder group, the costs and benefits of adopting the new system. Apart from

providing a clearer view about how acceptable the system will be to each group, it can help in identifying possible solutions to increase acceptance of the system. This is a good way of investigating how to increase the relevance and long term sustainability of the project, but in order for it to be realistic, it is recommended that local partners are involved. This helps to reduce the risk that the resulting analysis is culturally biased.

The *Task analysis* method is usually applied in the current or competitors' systems, in order to understand how users achieve their goals. The main goal of a task analysis is to represent in detail the components of a task, the information flow within the system and the users' cognitive processes while performing the task. When developing for low-literacy users, however, one might need to broaden the application of the task analysis method to include not only current systems (which might not exist at all), but also the current, non-technological ways of carrying out a task. Investigating tasks this way can yield interesting data, providing information especially with regard to possible metaphors, input and output modalities, possible GUI characteristics, and even some insights on the characteristics and needs of low-literacy users. One example is the work carried out by Parikh (2005), where the evaluation of the intensive use of paper forms by users in their everyday life resulted in the development of an application that leveraged that use and incorporated it to the information ecology with the use of mobile phone cameras, instead of dismissing this existing practice completely.

However, to be able to get a good idea of how users perform the task currently might need other observation methods (design probes, interviews), and possibly the involvement of local partners to help in the mapping of how users currently achieve their goals.

Scenarios of use are documents that give examples on how users carry out tasks in determined contexts, and should ideally include situations that give a good idea of the whole concept of a system, and how and why the users expect to use the system. *Personas* are caricatures, rich fictional representations of a group of users, with names, personalities and even pictures. Both methods are often used in conjunction to help evaluate user needs when using the system, especially when it is hard to involve actual users in the requirements gathering phase. If written carefully, based on information gathered from other sources (such as design probes and surveys) and with the help of local partners, scenarios of use and personas can

serve as valuable tools to investigate user characteristics and also to give insights on features of the application design, related to how the interface will look like and how the interaction with the software or device will happen.

Hypothetical User Design Scenarios (HUDS) is in fact a structured framework that guides the application of many UCD methods, especially scenarios of use and personas, in a way that helps researchers and designers determine the general shape of the interface and reserve the testing for later phases of the development cycle. This is achieved by the creation of very detailed Hypothetical User Design Scenarios, based on investigation of the relevant issues that might impact the designers' judgement. This framework was created by Huenerfauth (2002b) during a project to develop user-interface guidelines for applications aimed at illiterate users, when it was impossible to have direct access to those users.

The Hypothetical User Design Scenarios framework can be split into two different phases. The aim of the first phase is to determine the background information needed to start the development process, based on the conceptual model for Human Computer Interaction presented by Eason (1991) and adapted by Preece et al. (1994, p. 43). This model identifies four components and assumptions that have to be understood by the designer: users, environment in which the system will be used, the work which users will perform with the system, and the technology which will be used in it. The model requires the discussion of not only the intrinsic characteristics of each component, but also how they relate to and interact with each other, that is, how the change in one of the components affects the others.

In the second phase the actual scenarios are created, based on the background information collected previously. Each scenario is further developed into a detailed script of the interaction. The script is then analysed: the researchers list issues that might affect the use of the interface and they also enumerate open research questions. At this point, the cycle is suspended temporarily while open questions are investigated with other methods such as usability tests, surveys, design guidelines, etc. After the relevant points have been clarified, a new iteration can start, drawing on the questions raised previously and using new scenarios to explore them.

The advantage of the Hypothetical User Design Scenarios, in comparison to normal scenarios of use and personas, is that it guides researchers and designers to exploring more deeply certain questions pertaining especially to the influence of

Phase	Explanation
Synopsis	Presents a short description of the script.
Entities and Characters in the Scenario	Presents a more detailed investigation of the user, the technology, applications and usage environment of the application, and then the locations, organisations, individuals and other relevant issues, each one in its own subsection.
The Scenario Script	The task that the HUDS is supposed to specify is detailed, step by step. The designer can list alternative options as well.
Analysis of Issues in the Scenario	The designer identifies the critical points raised in the script and in this section lists them one by one, together with considerations about problems, possible pitfalls, and maybe even some ideas about how to solve the problem.
Areas of Future Research Highlighted	Based on the issues listed in the previous step, the designer lists the open research issues that have to be explored in order to improve the design of the interaction.

Table 11: Hypothetical User Design Scenario framework, based on Huenerfauth (2002b).

characteristics of the environment and of the users. It also has an inherently iterative nature that is likely to result in a more accurate scenario and script of interaction.

In his original description of the framework, the author does not mention the possibility of validating each iteration of the scenarios with local partners. This can be a valuable addition to the method, that can help corroborate the information collected about users' characteristics, and confirm (or refute) the outcomes of the script regarding graphical user interface characteristics and input and output modalities.

As seen in the evaluation presented in this section, traditional methods for requirements gathering have a good potential to be applied at a distance and to properly support development of applications for low-literacy users. For that, it is necessary that researchers and designers always question their own assumptions and preferably cross-check and validate the outcomes of their analysis.

Contrary to the other traditional requirements gathering methods, task analysis seems to provide good support to the understanding of the current needs of users, even when applied without any adaptations. The evaluation of the Hypothetical

User Design Scenarios, created to address specifically the situation of distance design aimed at low-literacy users, indicated some adaptations that can further improve the methodology.

8.4 Design

When the time comes to **produce design solutions**, the research team should have enough information to generate alternatives. During this phase, the checklist provided by the framework proposed in this thesis can be useful, as it draws the attention to the most common needs of low-literacy users, common pitfalls, what to look for in the design and what to avoid.

	Framework questions									
Methods	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Brainstorming					□	□	□	□	□	□
Parallel design					□	□	□	□	□	□
Design guidelines and Standards		×	×		×	□	□	□	□	□
Interface design patterns		×	×		×	□	□	□	□	□
Paper prototypes		□	□	■	■	□	□	□	□	■
Storyboards		□	□	■	■	□	□	□	□	■
Delegating tasks to community	■	■	■	□	□	□	□			□

Table 12: Evaluation of methods for the design phase

Brainstorming is a technique to stimulate creativity that consists of two phases: free generation of ideas and evaluation of the outcomes. Apart from providing an environment for ideas to be created, a brainstorming session also gives participants an opportunity to better understand the problem. In the *Parallel design* method, a set of two to four alternative designs are created at the same time by groups working independently. At some point, a workshop is organised between the teams, and the resulting design might be a combination of the best ideas from each solution. In both methods, it is necessary to constantly refer back to questions 5-10 proposed by the framework, to make sure that the solutions incorporate the needs of low-literacy users.

Although design techniques employed in the User-Centred Design approach typically do not involve users directly, some researchers argue that the participation of users in design efforts is valuable and should be pursued (Bødker and Nielsen, 2008). In the case of software and applications aimed at low-literacy users in developing regions, this involvement might be a good way of ensuring that the resulting design incorporates the needs of that user group. Direct user involvement can be difficult for numerous reasons, many of them already mentioned in previous sections of this chapter; however, local partners can provide valuable contribution, and should possibly be involved.

Design guidelines and standards and *Interface design patterns* are two sources that give designers valuable guidance based on previous experience and research. However, by using such resources, most of them created with other users in mind, without thoughtful consideration, researchers risk overlooking important issues related to cultural differences and user characteristics. There are several user interface standards and guidelines, especially related to accessibility of websites and of software, and many websites with catalogues of UI design patterns, but very few of them address the needs of low-literacy users specifically. One exception is the work by Medhi et al. (2006), who presented a set of design principles for text-free UIs, created from observations made in field studies conducted in communities of illiterate domestic labourers from Bangalore slums in India.

Paper prototypes, or mock-ups, are a cheap and fast way to clarify concepts, explain ideas and identify potential usability problems. *Storyboards* can be considered a type of low-fidelity prototype, used to give a good overview of a designer's ideas by using a series of sketches to illustrate the functionalities of the system. Both methods can be used by the team to discuss the system among themselves, but also with local partners and even with users. In fact, Rachovides et al. (2007) identified that, in the development of devices, cardboard prototypes might be useful for tests with users from developing regions, as they remove the fear of breaking real devices. Being low-fidelity artifacts, they are easy to transport and can even be digitalised and sent overseas via the internet. Videos can also be made with a presentation of the prototype or storyboard and sent on-line to local partners, who can then give their impressions or collect feedback directly from users. Feedback from local partners or from the users themselves can help in giving insights on users characteristics related to illiteracy.

If the designers decide to show the prototypes to users to collect impressions, it is important that they are made considering the type of language and metaphors used in the presentation. In addition, local cultural references can be used in the storyboard to facilitate the understanding of the functionalities being presented (local cartoons, soap opera characters, known places, etc.).

Delegating tasks to community is an approach proposed by Alvarez (2008), who suggests that there are some parts of the effort of creating user interfaces for low-literacy users that can be performed by the target community itself, in particular the creation of localised content. This approach not only allows for the creation of software and content that is likely to be much more relevant to the community, but also encourages creativity and capacity building among the users.

Of course, delegating tasks to the community cannot be done without serious work in creating the right environment for that to happen in a way that understands the limitations in the skills of those users, their need for gradually getting involved with time to learn how to participate, and the language and metaphors that they understand and that leverage their participation in the design process. It is also important to make sure that the participation happens in a way that fulfils their needs and makes them comfortable with the participation, feeling empowered.

Producing design solutions is a phase that typically does not involve users, so the methods that can be used at a distance are basically the same for researchers working with local users or users in remote locations. As in the stage of gathering requirements, it is important that designers constantly question their assumptions, look for references in previous work and guidance from local experts. Examining the evaluation presented in this section, it becomes clear that the HCI community could benefit from clear and structured heuristics and guidelines, made specifically with low-literacy users in mind. There is also the innovative effort of delegating some of the design tasks to the target community, which looks promising.

8.5 Evaluation

After the design phase, the User-Centred Design approach foresees the need to **Evaluate designs against user requirements**. The research community understands

that direct participation of users in this phase is particularly important, as this is when the team checks if the resulting product is usable and suits the needs of its target users. As the UCD process is inherently iterative, if the evaluation proves that there are problems with the design, a new cycle is started so that the issues are investigated again, and new design options are generated and evaluated, until a satisfactory result is produced.

However, for research projects carried out at a distance, directly involving users from developing regions can be difficult and expensive, and sometimes simply impossible. Instead of dismissing completely the feasibility of the project, here we try to consider the alternatives. This is why the evaluation presented below is restricted to methods that do not require that the research team is physically in the same place as their users.

	Framework questions									
Methods	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Heuristic evaluation		×	■		×					
Satisfaction questionnaires		□	×	×	□		□	□	□	
Usability evaluation at a distance		□	×	×		□	□	■	■	□
Usability testing with similar users		□	□	□	□		□	□	□	

Table 13: Evaluation of methods for evaluating design against requirements

In a *Heuristic evaluation*, a group of experts in usability evaluates the interface against a list of existing and well-known usability heuristics. Problems found by the experts are consolidated and ranked according to severity. It is a relatively cheap method for evaluating a system, as two or three experts typically identify most of the problems. As it happens with the use of guidelines, standards and design patterns, the biggest issue with heuristic evaluations is the lack of established heuristics directly addressing the needs of low-literacy users. Nevertheless, Nielsen's (1994) second heuristic principle, **Match between system and the real world**, addresses directly the issue raised in question 3 of the framework: "The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms."

Satisfaction questionnaires capture the subjective impressions of participants after using the system. Those impressions can be collected using questionnaires,

composed mainly of closed-ended questions, or through direct communication with users. If well developed, user satisfaction questionnaires can be helpful in identifying what works and what does not in interfaces and devices for low-literacy users. Nevertheless, like surveys, satisfaction questionnaires risk looking too "official" and may create resistance in participants, preventing them from answering the questions honestly, or cause them to try to please researchers with positive answers.

Usability evaluation at a distance, or *remote evaluation*, consists in a usability evaluation where the evaluator is separated in space/time from the user (Hartson et al., 1996). It was created as a solution to problems created by the expansion of software use across networks, as it became more difficult to recruit users for usability tests and to reproduce work conditions in laboratories.

Remote usability evaluations can be divided in two categories: (1) synchronous, where evaluators and users are in different locations, but can interact in real time; and (2) asynchronous, where data is collected to be analysed at a later time and there is no interaction between participants and evaluators (Dray and Siegel, 2004). In this analysis, only the synchronous methods are considered, in particular remote evaluations using video conferencing as an extension of the usability laboratory. Asynchronous methods are left out of the analysis because they are essentially methods to collect quantitative data on the use of existing information systems. As such, they are of little relevance to the development of applications aimed at poor communities in the developing world.

Although remote usability evaluations can offer many advantages, especially related to lower costs and more flexible schedules, they also present great challenges, particularly in projects aimed at low-literacy users from developing regions. Subtle non-verbal cues can be valuable to understand cultural differences and to help interpret results obtained in the tests, but they can go unnoticed in a remote evaluation. The technological apparatus involved in performing remote usability tests, such as webcams, microphones and speaker phones, can be frightening to users who are not familiar with such devices. It is also important to keep in mind that infrastructure limitations might prevent the tests from running smoothly, and that can be very disturbing for participants. Local partners can be especially helpful in logistical arrangements.

Testing with similar users consists in identifying the main characteristics of the target user group and recruiting, as usability test participants, people who share

some of those traits and who live in the region where the research team is based. One example is the work carried out by Deo et al. (2004), who recruited foreign participants learning English as a Second Language in a local language school to help evaluate a digital library interface for illiterate users. However, those participants were literate in their own language and, as such, were familiar with certain cultural forms and possessed skills that the target user group possibly did not. This illustrates the need to consider that, although some aspects may be shared with the target user group, other characteristics of the recruited participants may affect the results of the evaluation. To avoid biases in the results, testing with similar users is an approach that has to be used with care and critical sense, preferably to investigate very specific issues, and in combination with other evaluation techniques.

Evaluating design solutions at a distance is a phase of the UCD process that is not very well supported by current methods. Traditionally among the HCI community, the evaluation phase is one where the direct involvement of users is considered very important, if not imperative. As a consequence, existing HCI methods do not satisfy the need of evaluating at a distance, especially when the target user has low literacy skills.

9. Discussion

The past few years have seen a significant amount of work done in the field of Information and Communication Technologies for Development, and in how Human-Computer Interaction can contribute to make a difference in the lives of poor communities. The experience and knowledge gathered are as rich and varied as the cultures studied by the ICT4D community over the last two decades.

Working with developing regions is an intricate task due to the huge cultural diversity among the different countries that are classified under the label of "Third World". Understanding and managing those differences is especially complex to those living in richer countries, as the ways of life, processes and problems are so distinct between the developed and the developing worlds.

Apart from the obvious cultural and language differences, some issues might be more hidden and easier to overlook, especially the ones that refer to subtle local cultural norms or to socio-economic distance between the parties involved in the project. These are probably the most challenging for cross-cultural projects, as they can easily remain unnoticed until very late in the process. Other topics are more practical, but no less important. Researchers can avoid many complications by planning extensively: considering possible recruiting, scheduling and infrastructure problems in advance is certainly more than advisable. Illiteracy itself also brings its own share of challenges. Low-literacy people are used to interact with the world in a very particular manner: they usually work in groups and with the help of other people from their communities. It is very important that their characteristics, preferences and needs are well understood by whoever intends to work for them or with them.

The framework presented in this thesis is an attempt to make that complexity more manageable. It tries to provide generalisations and identify which are the common characteristics and needs of illiterate and functionally illiterate users from several locations, and how those circumstances affect the creation of technology solutions for that group. The result is a tool that is succinct and practical, intended to be applied in one specific part of the problem: choosing which methods to apply in the production of software and devices aimed at low-literacy users in the poorer regions of the world.

As happens with all generalisations, this one also suffers from the loss of the nuances inspired by differences. The ten questions of the framework do not reflect all the multiplicity involved in working with low-literacy users from different parts of the world, but this simplification is necessary to classify and organise that diversity, in order to effectively deal with it.

This is why the framework for analysis of methods presented in this thesis must be regarded as an overall guide to researchers and developers, and not as a definitive prescription of what can and cannot be done. It is a reminder of the need to critically analyse possibilities and decisions in light of the differences between researchers and their target users, instigating discussion among team members and stakeholders. It can be of great benefit to combine the application of the framework with knowledge drawn from previous research and experiences to help in the evaluation of methods, increasing the likelihood that the choices made deliver the best possible results.

Apart from serving in specific projects to support decision-making, the framework for analysis presented here can also be used at a more theoretical level, providing the basis for future research to improve methodologies for the development of interfaces aimed at low-literacy users. Analyses of methodologies made using the framework can result in adaptations of existing methods or in completely new approaches that better satisfy the particular needs of this target group.

Most of the traditional methods used to support the User-Centred Design, for example the methods described by Maguire (2001) and Bevan (2003), are not suitable for development of applications aimed at users from the developing world, especially to those with low-literacy skills. This subject has been discussed at length, and so far most of the solutions suggested by the HCI and ICT4D communities rely on ethnographic work and heavy immersion in the target culture. Nevertheless, it is not always possible to have constant and direct access to local contexts. Distance development aimed at poorer regions is a matter that has received very little attention, and therefore there is still room for further examination. The framework presented in this thesis can be utilised to help investigate this issue, and Chapter 8 is a first step into that direction.

Considering the methods analysed in Chapter 8, one can notice that most of the UCD methods that are currently available for developing at a distance either need adaptations or simply do not apply when targeting low-literacy users from

poor regions. This can be observed in Table 7 (p. 40), indicated by the amount of empty squares and "Xs" resulting from the evaluation performed in that chapter. Existing methods do not seem to properly cover gathering requirements and evaluating design solutions. The stage of producing design solutions could be better covered: it could greatly benefit from the establishment of heuristics and guidelines made specifically with low-literacy users in mind. Specifying the context of use, on the other hand, appears to be better supported by existing methods, as at least two methods can be applied more effectively in this situation: design probes and task analysis. In addition, methods that were created specifically with those user groups in mind do seem to provide better support for development. The Hypothetical User Design Scenarios could be improved in some aspects, such as involvement of local partners, but in all it seems to provide helpful information to the research team. Delegating tasks to the community, which was also proposed as a solution to ensure that the local community has more participation in the design process of applications developed for them, satisfies many of the needs identified by the framework, even if it was identified that sometimes it might require a few adaptations.

The considerations in the previous paragraph indicate that, currently, the most critical phases of designing at a distance for low-literacy users, the ones that deserve the most effort and attention, are *Specifying user and organisational requirements* and *Evaluating designs against user requirements*. The ICT4D research community could benefit from studies investigating methods to specify user requirements, and, most importantly, to allow for evaluation at a distance.

A practical application

The text below illustrates a simplified and hypothetical scenario, in which the application of the framework presented in this thesis guides the developer in deciding which methods to apply in different phases of the development of an application aimed at low-literacy users.

It is important to notice that the decisions portrayed below are by no means the only possible choices. Each researcher or designer has their own preferences, and each situation requires thoughtful consideration on the best way to proceed.

Consider a graduate student from Finland working for a Finnish government project for sustainable development in poorer countries. The student

received funds to create a bus timetable application for low-literacy users in a major city in Brazil. Due to financial restrictions, she has very limited travel possibilities, and has to choose wisely when to go to Brazil and which tasks to perform while there.

The first step of the User-Centred Design approach is planning the process. By checking the questions presented in the framework, it becomes obvious to the student that, to properly identify the needs of the intended target users and to make sure that the end result actually fulfils its purpose, she firstly needs to identify and contact local partners to help her in the process. She then gets in touch with a research group from the local university, dedicated to public transportation. She also contacts a local non-governmental organisation that receives funding for promoting digital inclusion in a poor area of the city. This phase proves to be a lengthy one, mainly because of the time required to formalise the cooperation agreements between all three parties. The student knows, however, that it is a necessary step, as formal involvement of the partners is important to the long-term sustainability of the project.

It is also during the planning phase that she decides how to deal with a very important issue: the language barrier. The student identifies that most of the literature on public transportation in Brazil is available in Portuguese only, thus essentially inaccessible to her. In addition, no one from the NGO staff can speak English and hiring a translator would be very costly. But the head of the research group in the local university manages to indicate a Brazilian graduate student with sufficient English skills to participate in the project, as part of his own PhD thesis.

The help of the Brazilian student proves to be essential in the project, as his knowledge of the local culture and political context greatly contributes to the mapping of how the public transportation systems are run in Brazil. Contrary to the Finnish system, in Brazil the buses are run by private companies without an effective central control from the government, which increases the complexity of bus itineraries and timetables. It is also thanks to the Brazilian colleague that the Finnish student learns about the upcoming changes that will happen in the system, changes that have a high potential to impact the project in the near future.

In order to better understand how poor people in Brazil cope with illiteracy, the student decides to employ design probes, as it is a method that does not take users away from their familiar environment. The probes are created and administered with the help of the Brazilian student and of the NGO staff. References from a popular soap-opera are used to generate interest and create

rapport with participants. And to identify issues related specifically to the use of public transportation, the Finnish student prepares a short survey to be applied in person and verbally by the NGO staff.

The information gathered with the help of the local partners is used in the production of Hypothetical User Design Scenarios. Those scenarios are shared with the Brazilian student, who in turn translates the scenarios to members of the NGO. The Finnish student considers it important to validate the scenarios with the NGO staff, as they can point out possible flaws in the understanding acquired while specifying the context of use phase and help fine-tune the details.

Once a satisfactory scenario is defined, the design phase starts. The design process happens in close cooperation with both local partners. Paper prototypes and storyboards are digitalised and shared with the research group and with the NGO staff.

Once a first design solution is agreed upon, the Finnish student produces a more polished version of the prototype for testing. It is decided that testing should be done locally, as remote usability testing with a prototype is likely to result in problems, especially considering the unreliable internet connection of the NGO facilities. In addition, the student does not want to intimidate participants by employing technology with which they are not familiar.

The Finnish student schedules a three-week trip to Brazil, during which usability tests are performed in the NGO facilities. She takes the opportunity to use buses and the metro intensively and sees, with her own eyes, the reality of public transportation in Brazil.

As it can be seen in the story above, the framework can be applied in a very subjective manner, as a critical evaluation of the points raised in each question can already indicate which methods work better and which ones have the potential for causing problems to the research team. Nevertheless, performing a more objective evaluation, as the one presented in Chapter 8, can also prove to be helpful, especially in situations of more severe limitations.

10. Conclusions

Poverty elimination is a theme that has gained a lot of importance in the last two decades. Profound changes in the global political context, international agreements to reduce poverty and economic growth of countries such as Brazil, China, India and Russia are aspects that have drawn greater interest to the potential of information and communication technologies to improve lives of poor people in the developing world.

The research community on HCI and related areas was considerably affected by this trend. Interest in investigating how to effectively employ technology to foster development grew with the understanding that the problem involves more than just providing access to technology. It became clear that ICT4D was fertile ground for research and innovation, with the potential to positively affect the world. Conferences on Information and Communication Technologies for Development occur regularly, while conferences on other fields, especially in Computer Science and Human-Computer Interaction, dedicate workshops and special interest groups to the theme.

With all the attention, it is important that the effort addressed to the theme is well utilised, and that the information is organised in a way that enables constant and continuous improvement.

This work was an attempt to provide the classification and systematisation that allows for good and effective use of that knowledge.

The literature review performed on recent research on ICT4D and on development of interfaces for users with low literacy skills provided a rich, varied view on the many challenges brought by the theme. It was presented as a list of issues faced by researchers who work with low-literacy users from the developing world. Four main points for attention were identified, described in more detail and associated to the consequences that they bring to research in this area: the *cultural diversity* among the developing countries and the differences between those countries and the developed world; *characteristics of the environment* and *characteristics of the users*, both of which affect not only the design of the end product, but also how the whole process is conducted; and *recommendations for design*, which have been formulated

over the course of the past years grounded on research and experience, ranging from considerations on the use of graphics, colours, numbers and geographical references to the need to provide opportunities for progressive learning within the application.

This knowledge was analysed, categorised and summarised in order to facilitate the use and encourage its application. The result was a framework for analysis of UCD methods—a set of ten questions that help in the consideration of the most important issues that researchers and developers have to observe when developing applications aimed at low-literacy users in poor regions. Although it was designed with low-literacy users in mind, the framework can also be useful in any UCD project, because many of those challenges also exist in projects aimed at users from different backgrounds, even if in some cases it might be in a smaller scale.

As part of its refining process and to validate its potential to instigate discussion among the research community, the framework was used to evaluate a set of methods that support design at a distance, that is, development of applications when target users are separated geographically from the researchers.

The results of the evaluation indicated that distance design is a field that could greatly benefit from new and improved methods, better suited to the characteristics of low-literacy users. It is true that there are some methods, however few, that give good support to development in this particular situation, especially those that were created with users from poorer regions in mind, such as the *Hypothetical User Design Scenarios*, in the requirements gathering phase, and *Delegating tasks to community*, in the design phase. *Design probes* are good options to help identify the context of use, being an exploratory and non-invasive method that aims to give insights on the reality of users in their everyday lives. In addition, in almost all phases of the development, existing options can be applied, as long as developers and researchers make adaptations to make sure that the needs identified in the framework are met. Nevertheless, gathering user requirements and evaluating design solutions could still be better supported. For example, *Usability evaluation at a distance* seemed at first to be a feasible solution to the problem, but can bring many challenges related to infrastructure. It could be very helpful to the community to look into other usability evaluation methods that are currently performed face-to-face and try to adapt them to better suit evaluation at a distance, especially with low-literacy users.

Finally, it is important to emphasise that the framework should not be considered as something finished and immutable. There is an already significant and still

growing amount of research on the field of Information and Communication Technologies for Development, and due to the relevance of the theme, the expectation is that works on this area continue to appear. As more information is gathered from the field, it is possible that more considerations on developing interfaces for low-literacy users emerge. In that case, it is desirable that those points are incorporated in the framework, so that it remains up-to-date and relevant to the HCI and ICT4D communities.

References

Alvarez, J. M. A. (2008). Trust building user generated interfaces for illiterate people. In *Proceedings of the IUI'08 Intelligent User Interfaces for Developing Regions (IUI4DR) Workshop*, pages 38–42.

Bainbridge, W. S., editor (2004). *Berkshire encyclopedia of human-computer interaction*. Berkshire Publishing Group, Massachusetts, USA.

Baker, M., Reddy, R., and Bell, G. (2006). Interviews: The challenges of emerging economies. *Pervasive Computing, IEEE*, 5(2):40–46.

Barton, D. (1994). *Literacy: an introduction to the ecology of written language*. Wiley-Blackwell, Oxford, UK.

Bednarik, R., Kamppuri, M., Tedre, M., and Vesisenaho, M. (2007). Alternative to technology-driven development: An approach based on authentic needs. In *CHI'07 Workshop: User Centered Design and International Development*, San Jose, California, USA.

Bevan, N. (2003). UsabilityNet methods for user centred design. In Jacko, J. A. and Stephanidis, C., editors, *Human-Computer Interaction: Theory and Practice*, volume 1 of *Human factors and ergonomics*, pages 434–438. Lawrence Erlbaum Associates.

Bevan, N. (2009). International standards for usability should be more widely used. *Journal of Usability Studies*, 4(3):106–113.

Blake, E. H. and Tucker, W. D. (2006). User interfaces for communication bridges across the digital divide. *AI & Society*, 20(2):232–242.

Bødker, M. and Nielsen, J. (2008). Understanding relational practices in UCD. In *Proceedings of the Danish HCI Research Symposium*, pages 31–35, Aalborg, Denmark.

Brazilian Government (2007). e-MAG - modelo de acessibilidade de governo eletrônico. Available at http://www.governoeletronico.gov.br/acoes-e-projetos/e-MAG (accessed March 10th, 2009).

Brewer, E., Demmer, M., Ho, M., Honicky, R., Pal, J., Plauche, M., and Surana, S. (2006). The challenges of technology research for developing regions. *Pervasive Computing, IEEE*, 5(2):15–23.

Carroll, J. M. and Carrithers, C. (1984). Training wheels in a user interface. *Communications of the ACM*, 27(8):800–806.

Cheng, K. G., Ernesto, F., and Truong, K. N. (2008). Participant and interviewer attitudes toward handheld computers in the context of HIV/AIDS programs in sub-saharan africa. In *Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, pages 763–766, New York, NY, USA. ACM Press.

Chetty, M. and Grinter, R. (2007). HCI4D: How do we design for the Global South? In *CHI'07 Workshop: User Centered Design and International Development*, San Jose, California, USA.

Cockton, G. (2009). Understanding cultural differences in HCI: The diamond model of culture. Slides presented in the Cross-Cultural User Experience (UX) Design Seminar at Technical University of Tampere (TUT), in Finland on September 18th, 2009. Available at http://www.cs.tut.fi/ihte/projects/suxes/pdf/Cockton_Understanding%20cultural%20differences%20in%20HCI.pdf (accessed on October 5th, 2009).

Cremers, A. H., de Jong, J. G., and van Balken, J. S. (2008). User-centered design with illiterate persons: The case of the ATM user interface. In *Proceedings of the 11th international conference on Computers Helping People with Special Needs*, pages 713–720, Berlin, Heidelberg. Springer-Verlag.

Dearden, A. (2008). User-centered design considered harmful (with apologies to Edsger Dijkstra, Niklaus Wirth, and Don Norman). *Information Technologies and International Development*, 4(3):7–12.

Dearden, A. (2009). First, do no harm! How do we analyse the risks of unintended consequences? In *INTERACT 2009 Workshop: Ethics, Roles and Relationships in Interaction Design in Developing Regions*. Available at http://www.lkl.ac.uk/niall/i09/111_Dearden.doc (accessed on October 5th, 2009).

Dearden, A. (2011). HCI research for a better world: ethical challenges in HCI for

development. In *CHI'11 Workshop: Ethics, Logs and Videotape: Ethics in Large Scale Trials & User Generated Content*.

Deo, S., Nichols, D., Cunningham, S., Witten, I., and Trujillo, M. (2004). Digital library access for illiterate users. In *Proceedings of the International Research Conference on Innovations in IT*, pages 506–516, Dubai, UAE.

Dhakhwa, S., Hall, P., Ghimire, G., Manandhar, P., and Thapa, I. (2007). Sambad – computer interfaces for non-literates. In *Proceedings of the 12th international conference on Human-computer interaction: interaction design and usability*, pages 721–730, Berlin, Heidelberg. Springer-Verlag.

Dray, S. and Siegel, D. (2004). Remote possibilities?: international usability testing at a distance. *interactions*, 11(2):10–17.

Dray, S. M., Siegel, D. A., and Kotzé, P. (2003). Indra's Net: HCI in the developing world. *interactions*, 10(2):28–37.

Eason, K. (1991). Ergonomic perspectives on advances in human-computer interaction. *Ergonomics*, 34(6):721–741.

European Commission (2005). i2010—a european information society for growth and employment. Available at http://ec.europa.eu/information_society/eeurope/i2010/index_en.htm (accessed on March 10th, 2009).

Filgueiras, L., Martins, S., Correa, D., and Osorio, A. (2009). Personas para caracterização da experiência de uso de tecnologia pela população digitalmente excluída. In *Resultados do Workshop em Usabilidade, Acessibilidade e Inteligibilidade Aplicadas em Interfaces para Analfabetos, Idosos e Pessoas com Deficiência - IHC 2008 - VIII Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*, pages 15–22, Porto Alegre.

Findlater, L., Balakrishnan, R., and Toyama, K. (2009). Comparing semiliterate and illiterate users' ability to transition from audio+text to text-only interaction. In *Proceedings of the 27th international conference on Human factors in computing systems*, pages 1751–1760, New York, NY, USA. ACM Press.

Frohlich, D. M., Rachovides, D., Riga, K., Bhat, R., Frank, M., Edirisinghe, E., Wickramanayaka, D., Jones, M., and Harwood, W. (2009). StoryBank: mobile

digital storytelling in a development context. In *Proceedings of the 27th international conference on Human factors in computing systems*, pages 1761–1770, New York, NY, USA. ACM Press.

Gaver, B., Dunne, T., and Pacenti, E. (1999). Design: Cultural probes. *interactions*, 6(1):21–29.

Ghosh, K., Parikh, T. S., and Chavan, A. L. (2003). Design considerations for a financial management system for rural, semi-literate users. In *CHI '03 extended abstracts on Human factors in computing systems*, pages 824–825, New York, NY, USA. ACM Press.

Goetze, M. and Strothotte, T. (2001). An approach to help functionally illiterate people with graphical reading aids. In *Proceedings of the 1st International Symposium on Smart Graphics*, pages 39–43, Hawthorne, NY, USA.

Hartson, H. R., Castillo, J. C., Kelso, J., and Neale, W. C. (1996). Remote evaluation: the network as an extension of the usability laboratory. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 228–235, New York, NY, USA. ACM Press.

Heeks, R. (2008). ICT4D 2.0: the next phase of applying ICT for international development. *Computer*, 41(6):26–33.

Ho, A. T.-K. (2002). Reinventing local governments and the e-government initiative. *Public Administration Review*, 62(4):434–444.

Huenerfauth, M. (2002a). Design approaches for developing user-interfaces accessible to illiterate users. In *AAAI-02 Workshop: Intelligent Situation-Aware Media and Presentations (ISAMP)*, pages 23–31, Edmonton, Alberta, Canada.

Huenerfauth, M. (2002b). Developing design recommendations for computer interfaces accessible to illiterate users. Master's thesis, Department of Computer Science, National University of Ireland: University College Dublin.

INAF (2007). Indicador nacional de alfabetismo funcional: um diagnóstico para a inclusão social. Technical report, Instituto Paulo Montenegro/Ação educativa, São Paulo, Brazil. Available at http://www.ipm.org.br/download/inaf_brasil_2007_relatorio_sintese.pdf (accessed on March 10th, 2009).

ISO 13407 (1999). *ISO 13407:1999 (E): Human-Centred Design Processes for Interactive Systems*. International Organization for Standardization, Geneva, Switzerland.

ISO 9241-11 (1998). *ISO 9241–11:1998 (E): Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11 : Guidance on usability*. International Organization for Standardization, Geneva, Switzerland.

Jones, M., Harwood, W., Bainbridge, D., Buchanan, G., Frohlich, D., Rachovides, D., Frank, M., and Lalmas, M. (2008). "Narrowcast yourself": designing for community storytelling in a rural Indian context. In *Proceedings of the 7th ACM conference on Designing interactive systems*, pages 369–378, New York, NY, USA. ACM Press.

Júdice, A. and Júdice, M. (2007). Designing cultural probes to study "invisible" communities in Brazil. In *Proceedings of the 2nd Nordic Design Research Conference*, Stockholm, Sweden.

Kamppuri, M., Tedre, M., and Tukiainen, M. (2006). Towards the sixth level in interface design: Understanding culture. In *Proceedings of the 5th South African Human-Computer Interaction Conference*, pages 69–74.

Lalji, Z. and Good, J. (2008). Designing new technologies for illiterate populations: A study in mobile phone interface design. *Interacting with Computers*, 20(6):574–586.

van Linden, S. and Cremers, A. H. M. (2008). Cognitive abilities of functionally illiterate persons relevant to ICT use. In *Proceedings of the 11th international conference on Computers Helping People with Special Needs*, pages 705–712, Berlin, Heidelberg. Springer-Verlag.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human Computer Studies*, 55(4):587–634.

Martins, I. H., de Carvalho, L. A. V., Ferreira, L., Calháu, M. d. S. M., and Benício, M. L. T. (2003). Man-computer interaction aspects in systems for the young people and non-alphabetized adults. In *Proceedings of the Latin American conference on Human-computer interaction*, pages 235–238, New York, NY, USA. ACM Press.

Mattelmäki, T. (2006). *Design probes.* Publication Series A 69. University of Art and Design Helsinki, Finland.

Maunder, A., Marsden, G., Gruijters, D., and Blake, E. (2007). Designing interactive systems for the developing world – reflections on user centered design. In *Proceedings of the International Conference on Information and Communication Technologies and Development*, pages 321–328.

Maunder, A., Marsden, G., and Tucker, W. (2006). Evaluating the relevance of the 'Real Access' criteria as a framework for rural HCI research. In *Proceedings of the 5th South African Human-Computer Interaction Conference*, pages 75–79, New York, NY. ACM Press.

Medhi, I., Gautama, S. N., and Toyama, K. (2009). A comparison of mobile money-transfer UIs for non-literate and semi-literate users. In *Proceedings of the 27th international conference on Human factors in computing systems*, pages 1741–1750, New York, NY, USA. ACM Press.

Medhi, I., Prasad, A., and Toyama, K. (2007). Optimal audio-visual representations for illiterate users of computers. In *Proceedings of the 16th international conference on World Wide Web*, pages 873–882, New York, NY, USA. ACM Press.

Medhi, I., Sagar, A., and Toyama, K. (2006). Text-free user interfaces for illiterate and semi-literate users. In *Proceedings of the International Conference on Information and Communication Technologies and Development*, pages 72–82.

Ndwe, T. J. (2009). *Usability Engineering of an Interactive Voice Response System in Low Literacy Users of Southern Africa.* Doctoral dissertation in the department of electrical engineering, University of Cape Town, South Africa.

Ndwe, T. J., Sharma, A., Kgampe, M., and Kuun, C. (2008). Dialogue design for openphone system. In *Proceedings of the 2nd CSIR Biennial Conference*, Pretoria, South Africa.

Neerincx, M., Cremers, A., Kessens, J., van Leeuwen, D., and Truong, K. (2009). Attuning speech-enabled interfaces to user and context for inclusive design: technology, methodology and practice. *Universal Access in the Information Society*, 8(2):109–122.

Nielsen, J. (1993). *Usability Engineering.* Academic Press, Inc., San Diego, USA.

Nielsen, J. (1994). Ten usability heuristics. Available at http://www.useit.com/papers/heuristic/heuristic_list.html (Accessed July 6th, 2011).

OECD (1996). *Shaping the 21st century: the contribution of development co-operation*. Development Assistance Committee, Organisation for Economic Co-operation and Development, Paris, France.

OECD (2000). *Literacy in the information age: final report of the international adult literacy survey*. OECD and Statistics Canada, Paris, France.

Parikh, T., Ghosh, K., and Chavan, A. (2003). Design studies for a financial management system for micro-credit groups in rural india. In *Proceedings of the 2003 conference on Universal usability*, pages 15–22, New York, NY, USA. ACM Press.

Parikh, T. S. (2005). Using mobile phones for secure, distributed document processing in the developing world. *Pervasive Computing, IEEE*, 4:74–81.

Parikh, T. S. (2006). Mobile phones may be the right devices for supporting developing world accessibility, but is the www the right service delivery model? In *Proceedings of the 2006 international cross-disciplinary workshop on Web accessibility*, pages 143–146, New York, NY, USA. ACM Press.

Parikh, T. S., Javid, P., Sasikumar, K., Ghosh, K., and Toyama, K. (2006). Mobile phones and paper documents: evaluating a new approach for capturing microfinance data in rural India. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 551–560, New York, NY, USA. ACM Press.

Petersson, K. M., Reis, A., Askelöf, S., Castro-Caldas, A., and Ingvar, M. (2000). Language processing modulated by literacy: A network analysis of verbal repetition in literate and illiterate subjects. *Cognitive Neuroscience*, 12(3):364–382.

Plauche, M., Nallasamy, U., Pal, J., Wooters, C., and Ramachandran, D. (2006). Speech recognition for illiterate access to information and technology. In *Proceedings of the International Conference on Information and Communication Technologies and Development*, pages 83–92.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., and Carey, T. (1994). *Human-computer interaction*. Addison-Wesley, Harlow, UK.

Rachovides, D., Frohlich, D., and Frank, M. (2007). Interaction design in the wild. In *Proceedings of the 21st British HCI Group Annual Conference on HCI*, pages 91–94, Swinton, UK, UK. British Computer Society.

Rankin, Y., Thomas, J., and Ndwe, J. (2009). Tightly integrating cultural exploration and understanding into design. In *CHI'09 Workshop: Human-centered Computing in International Development*, Boston, MA.

Reddy, R. (2004). PCtvt: a multifunction information appliance for illiterate people. Talk presented at ICT4B retreat at UC Berkeley. Available at http://www.rr.cs.cmu.edu/pctvt.ppt (accessed February 1st, 2009).

Scribner, S. and Cole, M. (1981). *The psychology of literacy*. Harvard University Press, Massachusetts, USA.

Shneiderman, B. (2002). Promoting universal usability with multi-layer interface design. In *Proceedings of the 2003 conference on Universal usability*, pages 1–8, New York, NY, USA. ACM Press.

Sivakumar, T., Yabe, T., Okamura, T., and Nakamura, F. (2006). Survey design to grasp and compare user's attitudes on bus rapid transit (BRT) in developing countries. *IATSS Research*, 30(2):51–58.

Soloway, E., Jackson, S. L., Klein, J., Quintana, C., Reed, J., Spitulnik, J., Stratford, S. J., Studer, S., Eng, J., and Scala, N. (1996). Learning theory in practice: case studies of learner-centered design. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 189–196, New York, NY, USA. ACM Press.

Tambascia, C., Ávila, I., Piccolo, L., and Melo, A. M. (2008). Usabilidade, acessibilidade e inteligibilidade aplicadas em interfaces para analfabetos, idosos e pessoas com deficiência. In *Proceedings of the VIII Brazilian Symposium on Human Factors in Computing Systems*, pages 354–355, Porto Alegre, Brazil, Brazil. Sociedade Brasileira de Computação.

Taoufik, I., Kabaili, H., and Kettani, D. (2007). Designing an e-government portal accessible to illiterate citizens. In *Proceedings of the 1st international conference on theory and practice of electronic governance*, pages 327–336, New York, USA. ACM Press.

Thatcher, A., Shaik, F., and Zimmerman, C. (2005). Attitudes of semi-literate and literate bank account holders to the use of automatic teller machines (ATMs). *International Journal of Industrial Ergonomics*, 35(2):115–130.

Tongia, R. and Subrahmanian, E. (2006). Information and communications technology for development (ICT4D) - a design challenge? In *Proceedings of the International Conference on Information and Communication Technologies and Development*, pages 243–255, Berkeley, CA. IEEE.

Toyama, K. (2010). Human–computer interaction and global development. *Human–Computer Interaction*, 4(1):1–79.

Tucker, W. D. (2004). Connecting bridges across the digital divide. In *CHI '04 extended abstracts on Human factors in computing systems*, pages 1039–1040, New York, NY, USA. ACM Press.

UNESCO (2004). The plurality of literacy and its implications for policies and programmes: position paper. Technical report, UNESCO.

UNESCO Institute for Statistics (2005a). Literacy assesment and monitoring programme (LAMP). Available at http://www.uis.unesco.org/TEMPLATE/pdf/LAMP/LAMP_EN_2005.pdf (accessed on April 16th, 2009).

UNESCO Institute for Statistics (2005b). *Standards and Guidelines For the Design and Implementation of the Literacy Assessment and Monitoring Programme (LAMP)*. UNESCO. Available at http://www.uis.unesco.org/TEMPLATE/pdf/LAMP/11-%20LAMP_Standards_&_Guidelines_Dec2005.pdf (accessed on April 16th, 2009).

UNESCO Institute for Statistics (2008). *International literacy statistics: a review of concepts, methodology and current data*. UNESCO Institute for Statistics, Montreal, Canada. Available at http://www.uis.unesco.org/template/pdf/Literacy/LiteracyReport2008.pdf.

UNESCO Institute for Statistics (n. d.). UNESCO data centre. Database. Available at http://stats.uis.unesco.org (accessed on March 10th, 2009).

Unwin, T., editor (2009). *ICT4D: Information and communication technology for development*. Cambridge University Press, Cambridge, UK.

W3C/WAI Resource (2005). Introduction to web accessibility. Technical report, World Wide Web Consortium. Version 2.0. Edited by Shawn Lawton Henry, and participants of the Education and Outreach Working Group. Available at http://www.w3.org/WAI/intro/accessibility.php.

Warschauer, M. (2002). Reconceptualizing the digital divide. *First Monday [Online]*, 7(7). Available at http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/967/888 (accessed on October 23rd, 2009).

Appendix

A. Papers used in the review

The following table lists all papers from which data was collected for the analysis. This list includes research in both illiteracy and in Information and Communication Technology for Development (ICT4D). The theme of each paper is indicated in the last two columns of the table.

	Author(s)	Year	Illiteracy	ICT4D
1	Petersson et al.	2000	•	
2	Goetze and Strothotte	2001	•	
3	Huenerfauth	2002a	•	•
4	Warschauer	2002		•
5	Dray et al.	2003		•
6	Ghosh et al.	2003	•	•
7	Martins et al.	2003	•	
8	Parikh et al.	2003	•	•
9	Deo et al.	2004	•	
10	Reddy	2004	•	•
11	Tucker	2004		•
12	Baker et al.	2006		•
13	Blake and Tucker	2006		•
14	Brewer et al.	2006		•
15	Kamppuri et al.	2006		•
16	Maunder et al.	2006		•
17	Medhi et al.	2006	•	•
18	Parikh	2006		•
19	Parikh et al.	2006	•	•
20	Plauche et al.	2006	•	•
21	Bednarik et al.	2007		•
22	Chetty and Grinter	2007		•
23	Dhakhwa et al.	2007	•	•
24	Júdice and Júdice	2007		•
25	Maunder et al.	2007		•
26	Medhi et al.	2007	•	

(Continued on next page)

	Author(s)	Year	Illiteracy	ICT4D
27	Rachovides et al.	2007	•	•
28	Taoufik et al.	2007	•	
29	Alvarez	2008	•	•
30	van Linden and Cremers	2008	•	
31	Cheng et al.	2008		•
32	Cremers et al.	2008	•	
33	Dearden	2008		•
34	Heeks	2008		•
35	Jones et al.	2008	•	•
36	Lalji and Good	2008	•	•
37	Ndwe et al.	2008		•
38	Neerincx et al.	2009	•	
39	Tambascia et al.	2008	•	
40	Cockton	2009		•
41	Dearden	2009		•
42	Filgueiras et al.	2009	•	
43	Findlater et al.	2009	•	
44	Frohlich et al.	2009	•	•
45	Medhi et al.	2009	•	•
46	Rankin et al.	2009		•
47	Toyama	2010		•
48	Dearden	2011		•
Total			**26**	**36**